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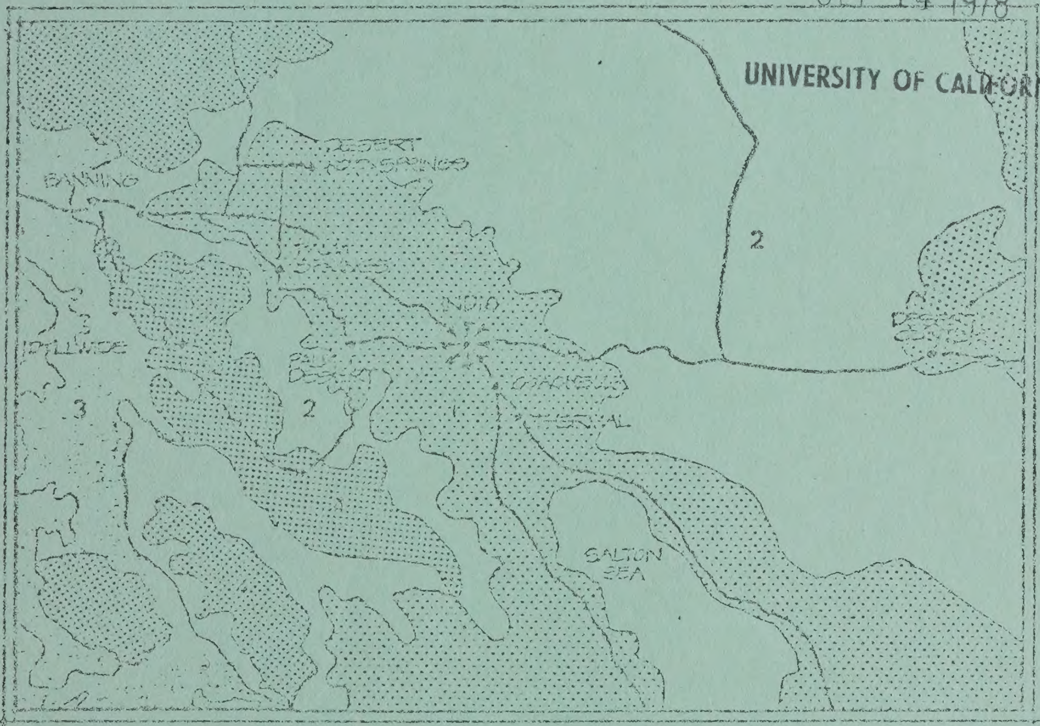
ENERGY CONSERVATION PROJECT



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DEPARTMENT OF PLANNING AND DEVELOPMENT, CITY OF INDIO, CALIFORNIA

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Indio
CALIFORNIA

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INDIO, CALIFORNIA
ENERGY CONSERVATION PROJECT

FINAL DRAFT REPORT
March 16, 1977

[Zoning systems]
Energy conservation -- Ca -- Indio
" -- policy -- " -- "

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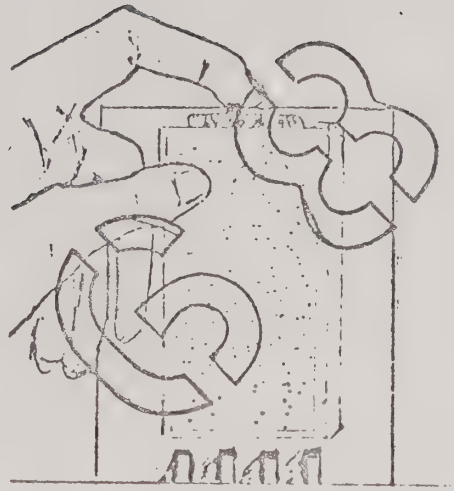
INTRODUCTION, CLIMATE ANALYSIS & ENVIRONMENTAL REVIEW

I. INTRODUCTION



I.1 OVERVIEW. The Federal government and State government in California have been particularly active in the past few years in identifying feasible means to reduce inefficient and unnecessary consumption of energy.

Local government has not played a particularly active role in energy conservation issues despite the fact that all development proposals are initiated and approved on this governmental level. Implementation of energy conservation standards which are oriented and designed for the particular regional area could result in a fifty percent reduction in consumption in this area of activity alone and could have a significant impact on energy resources, electrical energy supply, and consumer dollars spent on cooling and heating. Energy conservation is not a field that has been pre-empted by the State or Federal government; in fact, cooperation among all levels of government, industry and the public is essential to achieving energy conservation, and evidence of such cooperation is accelerating in the Southern California desert areas.

The Department of Housing & Urban Development (H.U.D.) commissioned the City of Indio, with the aid of Living Systems of Winters, California, to develop a local energy conservation program that promotes active local involvement in planning and implementing energy conservation. It is the intent of the Indio program to focus in on some specific issues that a City of its size and under similar constraints can implement, and to keep the books open to accommodate changes in laws and technology that are an inevitable part of the energy issue.

The subject project is intended to bring energy saving technologies and the benefits of science to desert residents through the development of pertinent local codes and policies. There was recognition that the implementation of energy conservation policies at the local level would have more impact upon the preservation of our natural resources as well as provide economic and climatic relief for area residents. The decision regarding the most applicable form or vehicle for implementing and influencing public decisions during the project approval process may be accomplished by one or more of the following. The major components of the Indio strategy for energy conservation are:

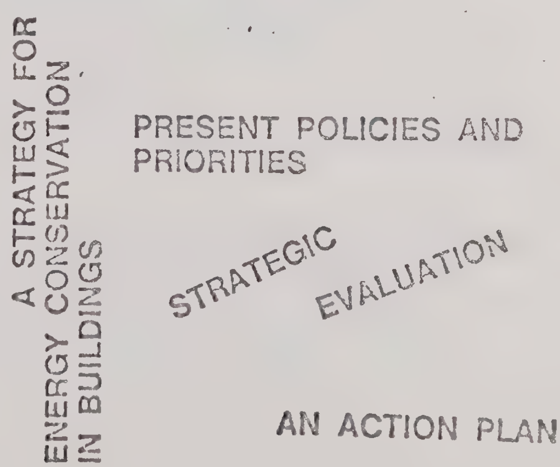
- Develop a climate analysis and data collection system which will complement and provide a basis for further investigation and research. (Section II Climate Analysis).
- Conduct simple experiments to provide data that is unavailable. (See Cool Pool experiment, roofing materials experiment) (Appendix C & D).
- Collect and analyze energy use data.
- Develop policies and procedures for a General Plan element and current planning efforts which will achieve energy conservation. (Section IV, Planning for Energy Conservation).

- Conduct a solar energy utilization analysis. (Appendix D).
- Review transportation modes and patterns. (Section V).
- City Administration. The City operations, fleet, and buildings consume substantial amounts of energy. Improving City operations can same money and energy and demonstrate to the citizens the enormous potential for energy conservation. (Section VI)
- Develop an energy conservation building performance code for new residential buildings in Indio. (Section VIII, Building for Energy Conservation).
- Develop an Environmental Impact Report checklist and guidelines. (Section III).
- Develop criteria and program materials for promotion of a retrofit program to promote and demonstrate energy technologies gains as a result of this project. (Appendix G).

This report also contains additional information which may be used to reveal energy relationships and evaluate their impacts. An Environmental Impact Report (EIR) checklist, which will be used to indicate mitigating measures, is a part of this report. Also, a supplement to the EIR Guidelines is included to assure accurate reporting of proposed developments' energy impacts.

This program is not an attempt to present a single strategy for achieving energy conservation, but rather a recognition of administrative and physical techniques which will provide energy conservation methods suitable for application in the Coachella Valley. Potentially, some of the techniques presented will be applicable to other jurisdictions; but Indio's unique local conditions are presented in this report. A summary of the administrative and physical techniques to conserve energy is presented in I.2 of this report. Detailed descriptions of physical techniqu that may be used by architects, developers, and builders are outlined in Section IV, V and VIII, and Appendix A of this report.

I.2 <u>SUMMARY OF ADMINISTRATIVE AND PHYSICAL TECHNIQUES</u>. This program will put to use a variety of administrative techniques that will require or encourage energy conservation. The physical methods available to architects, developers, and builders for achieving the desired degree of energy conservation are spin-offs from the administrative techniques and are described in various sections of the report. This section provides a very brief summary of the administrative and physical methods which can be used to implement energy conservation measures on development.



Administrative Techniques. The administrative techniques available to local governments to encourage energy conservation are listed below:

- General Plan. A General Plan Energy Conservation Element is proposed which will outline the goals, objectives, and policies of the City as they relate to the use of energy and the physical development of the City. The State of California does allow, as a permissive element under Section 65302(j) of the Government Code, for its inception:

  > (j) Such additional elements dealing with other subjects which in the judgment of the planning agency relate to the physical development of the county or city.

  Once adopted, this Element of the general plan will serve as a guide for community-wide energy conservation methods and for the implementation of the goals and policies of the element on proposed development.

- Zoning. The zoning ordinance is a useful planning tool to control and implement the policies and objectives of the General Plan Element. A number of changes are proposed to the present zoning ordinance which, if adopted, would present a number of alternatives for the implementation of energy conservation measures.

- Environmental Impact Review. Environmental impact review is an additional administrative tool that would help in the review process of individual projects, their design, and the mitigation of any adverse impacts. Through the EIR process, evaluation of an individual project to determine its impacts, if there is a significant effect upon the environment. Decision-makers can then institute or require methods to reduce adverse impacts and to consider alternatives to the project such as design alternatives to the structure in order to reduce energy impacts.

- Building Codes. Supplement the present building code with additional specifications that would require energy conservation construction practices. Requirements will take the following basic forms:

  - Require energy conservation building standards.
  - Outline performance standards for all new residential construction.

- Subdivision Map Act. Control of subdivisions is administered through the City Council and Planning Commission. Additional development standards made by the municipality or local jurisdiction can be imposed upon the developer in order to bring uniformity to subdivision development, and conformance and consistency to general and specific plans.

Physical Techniques to Encourage Energy Conservation. The physical techniques for energy conservation can be grouped into the following categories:

- Energy conservation site planning.
- Street design.
- Environmental review.
- Energy building code.

These physical techniques vary widely in their energy conservation reduction characteristics, their costs, and especially in their application to specific locations and conditions.

Energy Conservation Site Planning. Energy conservation site planning offers alternative site designs in the form of lot widths, lot areas, setbacks and yard requirements in order to minimize adverse energy impacts. Opportunities for successful site planning are determined through the administrative process. In general, present zoning patterns lack the flexibility necessary to permit innovative site planning techniques. Energy conservation site planning techniques recommended include:

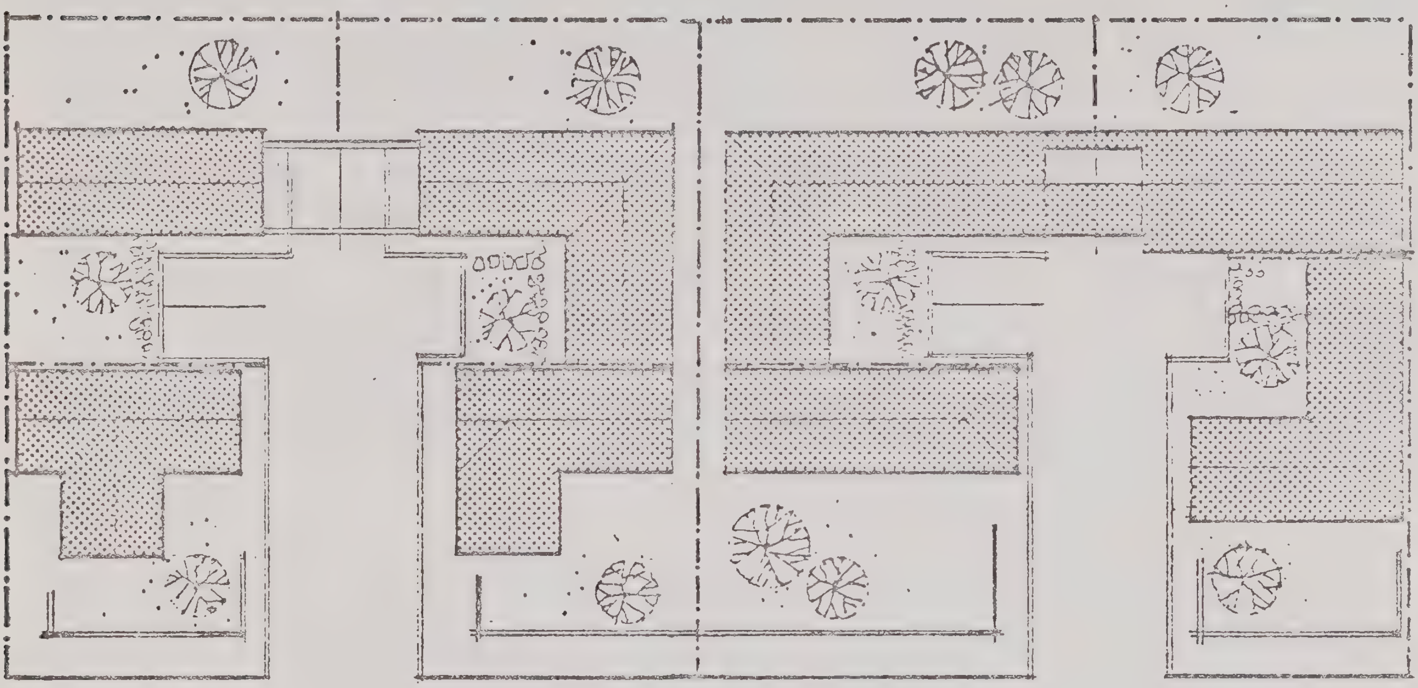
- Reduction in minimum lot width and size in all zoning categories that pertain to dwelling units.
- Reductions in yard requirements.
- Architectural design to include orientation, window placement, etc.

Street Design. Street design is a critical factor in energy conservation planning. It is demonstrated in the report that the energy investment in wide streets not only encourages sprawls and increases reliance on the automobile, other life cycle costs are incurred. They include: construction and maintenance, increased amounts of asphalt and concrete and increased difficulty in the shading of the street, thereby creating higher air temperatures and radiation to a property owner's surrounding micro-climate.

Environmental Review. Environmental review includes those energy conservation considerations connected with transportation and street systems, building designs, land use considerations and landscaping, particularly as related to commercial areas. These considerations are outlined in the checklist for energy conservation and addendums for the City staff, and environmental review of the Guidelines for each individual project. It is intended that mitigating measures, in terms of energy conservation, will be reviewed and commented upon at a very early stage in a project's review.

Energy Building Code. An energy building code is also included in this report. This code incorporates energy conservation concepts in the details of individual buildings. The areas of concern include building height, window placement, shading, etc. Building construction will require the treatment of the building to reduce energy conservation impacts. It includes implementation of some energy-conscious techniques to walls, windows, doors and ceilings to reduce heat infiltration into a building. The report indicates that energy conservation methods, if implemented during the earliest stages of project development, need not be prohibitively expensive in new construction.

Shown below is an example of the use of the energy conservation concept. The concept is a courtyard type development on those types of lots proposed in the text of this report. Note use of zero side yard and open courtyard.



COMPACT COURTYARD DEVELOPMENT

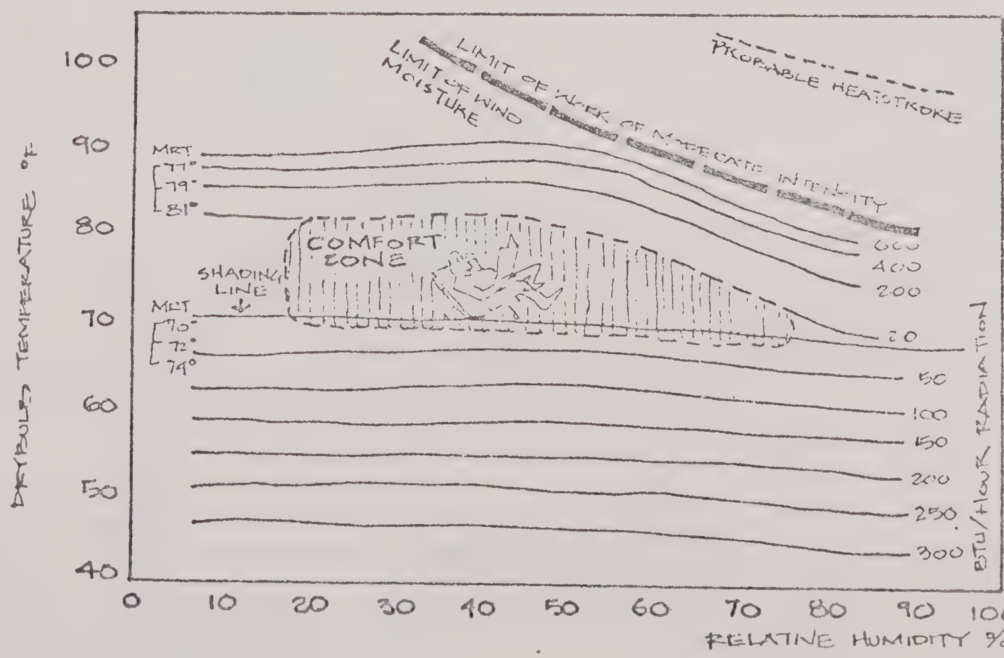
II. CLIMATE ANALYSIS

Mankind has adapted to life in climates ranging from the hot, arid deserts to the cold Arctic ice. Climate strongly influenced life style, clothing, shelter and the pattern of development until energy became artifically cheap. Air conditioning, heating and lighting with massive energy inputs have made one style of building and city liveable (if not comfortable) in both the American deserts and the very coldest parts of the Northeast.

The climate of the Coachella Valley is much like that of Phoenix and Yuma, Arizona, as well as parts of Israel and South Africa. It is possible to design dwellings for human comfort in this environment without electrical or mechanical air conditioning devices. A careful examination of the human physiology is an important consideration in any design strategy.

Human comfort is the result of a complex set of interactions between the physiology of our bodies and the physical environment that surrounds us. The human body is always generating heat (commonly about as much as a 100 watt bulb), and we feel comfortable when the rate of heat loss is balanced by the rate of heat gain. Our metabolic rate varies considerably between activities and poses a challenge for the building designer, e.g. a room temperature comfortable at rest would be stifling for hard work. Fortunately, the human body is very adaptable; and through changes in respiration, perspiration, and circulation rates, we can feel comfortable in a wide variety of settings. The pioneering work of C.E.A. Winslow resulted in a chart of the "comfort zone".

The human body loses heat by convection and radiation as well as evaporation from both the skin and lungs. These processes are all governed by physical laws yet can be modified by physiologic changes in blood flow, sweating, and metabolic level. The response of the body is complex and includes both short term and long term changes in these parameters. Adaptation to the desert is a real phenomenon, and the body can learn to tolerate more heat with less water loss. This adaptation causes Indio residents to feel chills on even relatively warm winter days.

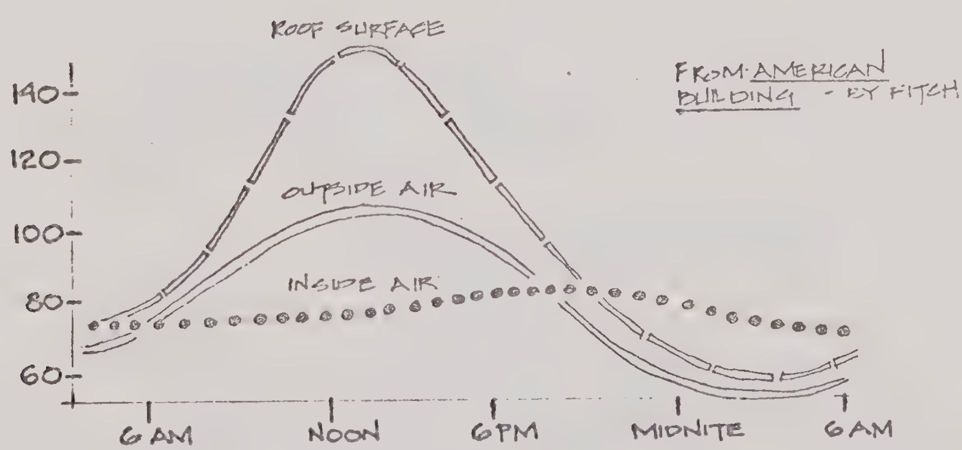


BIOCLIMATIC CHART (V. OLGYAY. 1963)

Proper design practices work with the body's control mechanism to achieve comfort, rather than setting an arbitrary, constant air temperature (without concern for humidity, wind, and radiation) that is theoretically comfortable yet surprisingly unsatisfactory. This approach was called the "bioclimatic approach" by Victor Olgyay; in his book, Design With Climate, he discusses in considerable detail the design requirements for comfort in Phoenix. With appropriate modifications for the slight climatic differences, similar design strategies can be developed for Indio.

II.1 CLIMATE, BUILDING AND HUMAN COMFORT IN INDIO. The basic goal of building design in Indio is the amelioration of high summer daytime temperatures. The more modest concern is the provision of heat during the short, cool periods in winter.

The basic principles of natural heating and cooling have been known and practiced for thousands of years. Yet, short-sighted energy and investment policies have generated designs and buildings that are energy wasters. Billions have been spent studying nuclear reactors; yet, few experiments have been undertaken to determine how the various components of a house work. The research that has been done has been done by a dedicated group. Harold Hay, F.A. Brooks, Loren Neubauer, Richard Cramer, Victor Olgyay, Baruch Givoni, and many others have advanced human understanding in a field much more important than nuclear physics; yet they remain completely unknown outside the small group of researchers carrying forward their work on naturally heated and cooled buildings. The graph shows how much better an adobe house works than a typical frame house.

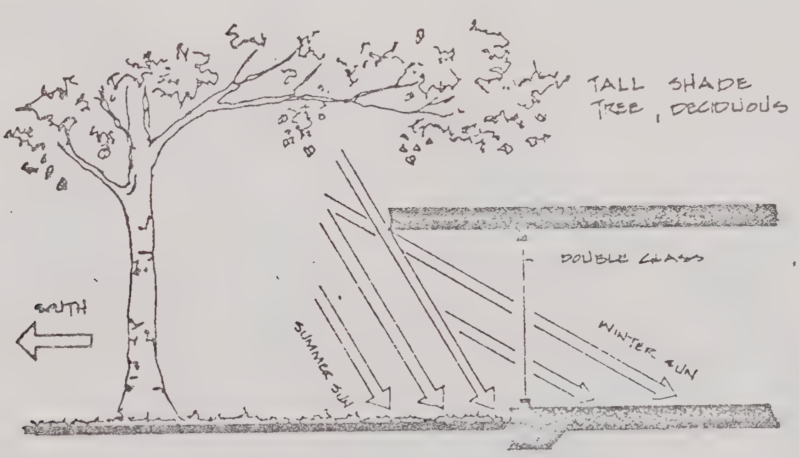


THERMAL MASS AS A BENEFICIAL CLIMATE MODIFIER

Note: The inside air temperature is very flat with the maximum occuring 8 hours after the outside temperature maximum. A typical frame house would have an inside temperature curve which would peak with the outside air temperature at a level of only a few degrees lower.

Radiation is generally the most important factor in heat transfer, which includes both the incoming solar radiation (short wave) and outgoing long wave radiation. Radiation is transmitted from a hot surface to a cooler surface, and this fact makes natural heating and cooling possible. Radiation can be reflected, absorbed, emitted, or transmitted when it strikes a surface. If we wish to heat things up, we want to absorb the radiation, converting it to heat. If we wish to keep things cool, we try to maximize reflection and emmissivity. The orientation and shape of a house have predictable effects on radiation gain and loss. These effects have been studied extensively in experiments by Neubauer, Cramer, Olgyay, Givoni, and others.

The sun is the key to understanding radiation flow. In the winter we want to capture the sun's energy, while in summer we need to reject it to prevent overheating. To do this, it is important to have an understanding of how the earth's position relative to the sun changes with the seasons. The sun's position is described by its height above the horizon, altitude, and its bearing from the true south, azimuth. The change in elevation and azimuth over the seasons is a critical aspect of design with climate. In Indio, at about 32 degrees north latitude, the sun is at an altitude of 34 degrees at noon on December 21 and over 80 degrees during the summer. In summer it traverses an arc of 220 degrees from east to west, while in winter it only covers 106 degrees. South facing windows offer the special advantage of being excellent sources of free solar heat in the winter, while they can be easily shaded in the summer months by a simple overhang. With enough heat absorbing mass inside the house, a south-facing window can be much better than the best insulated wall because it collects needed winter sun while not letting in unwanted summer heat.



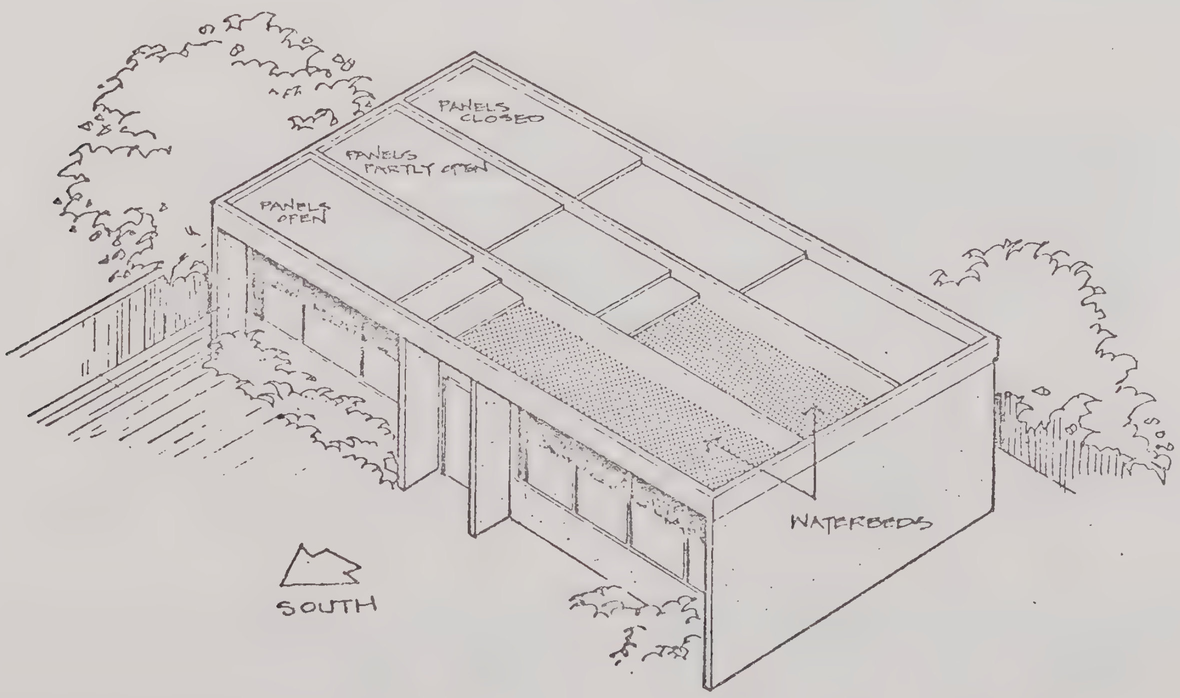
SOLAR WINDOW

The excess heat that builds up inside a house on a hot day can be reradiated at night to the cool night sky or during the day to the cool north sky, which may be significantly cooler than the south sky. The hot roof can see the cold upper atmosphere if humidity and dust are low and radiate heat away very rapidly. This effect has been used to make ice in the desert when air temperatures reach only 40 to 45 degrees.

Second in importance is convection, or the transfer of energy through air flow. This may be flow caused by local differences in density of air (cooler air is heavier) or weather patterns with their characteristic flow. The flow of air in and out of a building is affected by design and placement of vents, windows, interior walls, external building elements and the activities of the occupants. Most areas of California recently experienced chilly cold due to a strong north wind and temperatures in the low forties. During these "peak" events, heat loss due to infiltration becomes extreme as the wind whistles in through the house. Even in light wind conditions, one-half the unwanted heat loss can occur due to infiltration.

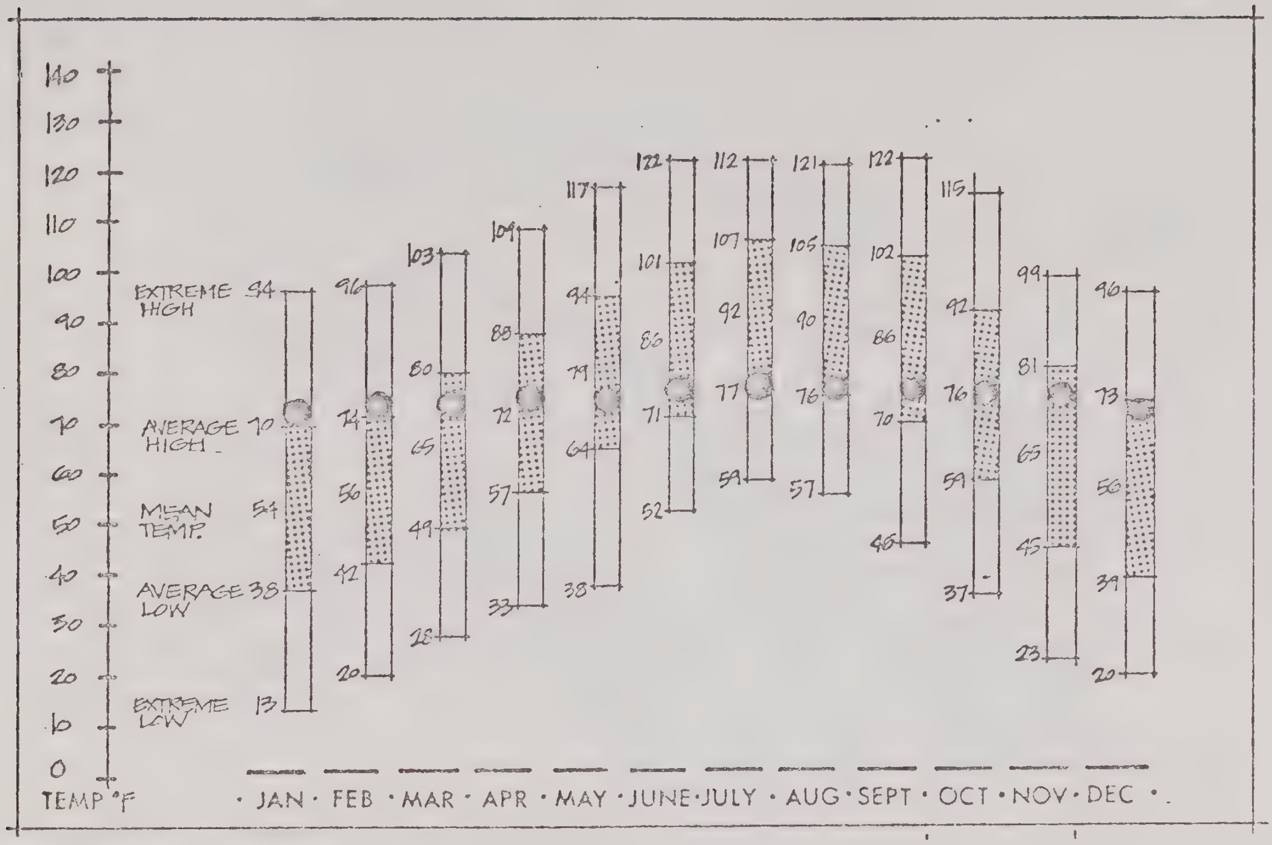
The third type of heat flow is from molecule to molecule and is called conduction. This is an important design consideration in Indio. Insulation has very high resistance to heat flow and slows down heat gain or loss. Windows can be a major problem because their resistance ("R" value) is only about 0.9, and double pane is 1.6. Yet a standard insulated wall has an "R" value 12.5 to 20, and a ceiling with 8 inches or more of insulation has an "R" value of 26 or more. Insulated shutters or carefully designed thermal drapery systems can increase window resistance to values over 6, and thereby greatly improve the performance of a building.

Evaporation is the last type of heat transfer. It is important in Indio because considerable energy is absorbed in changing water from a liquid to gaseous phase which can made a surrounding area cool. The cheapest evaporative cooler is a large tree, but a "swamp" cooler may also be used. Fountains and pools also reduce heat effects by cooling the physical and psychological micro-climate (see the Planning Section of this report).



SKYTHERM HAY HOUSE

Cooling Mode Operation
Panels opened at night to allow radiant loss from the waterbeds. During extremely hot months the tops of the waterbeds are covered with layer of water to add evaporative cooling. Panels closed during the day.



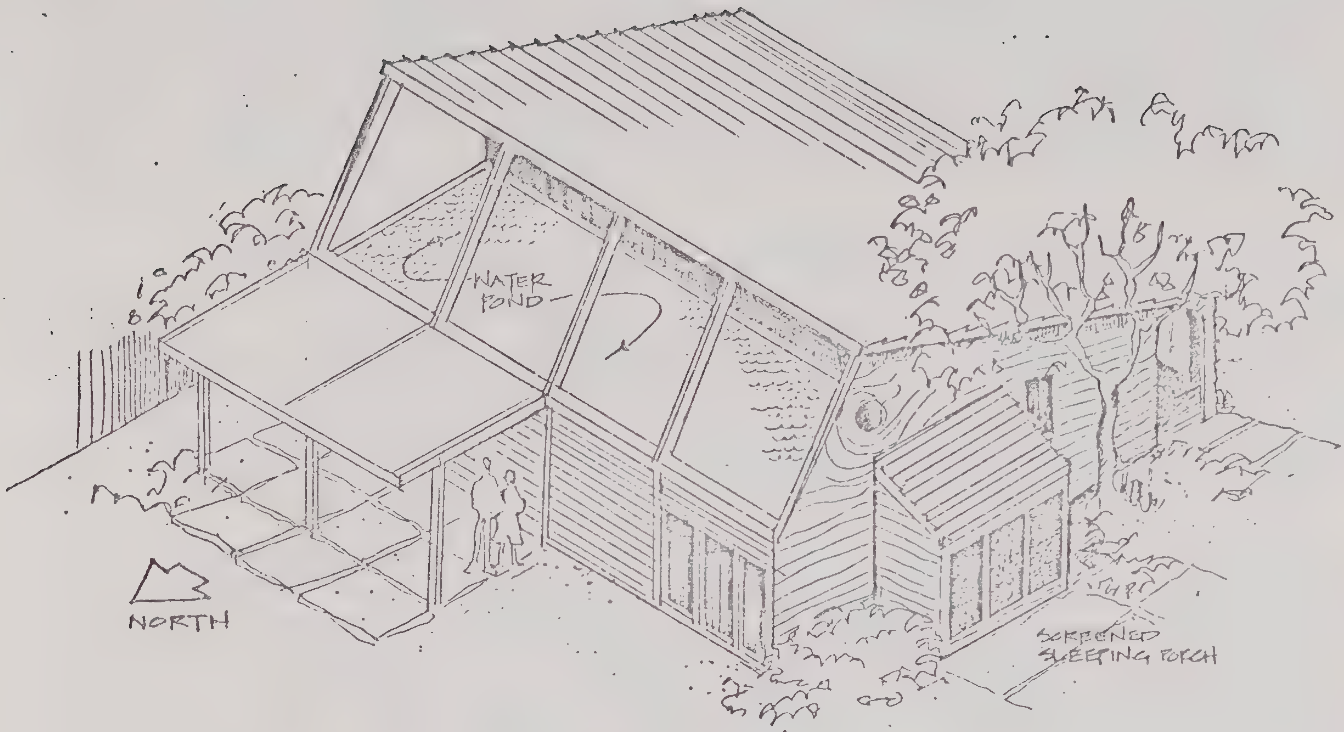
Performance of Hay Skytherm Prototype Superimposed on Indio Temperature Data

Data adapted from that published by H.R. Hay and J.L. Yellot. Top of dot is the average daily maximum. Bottom of dot is the average daily minimum.

After care has been taken to have as much beneficial heat transfer as possible into and out of a structure, its heat storage potential or thermal mass becomes an important consideration. The massive adobe walls of the old missions are a classic example of the value of thermal mass. Recent energy saving homes using barrel walls, water tanks, water columns or earth berms are also using thermal mass to store "heat" or "cool" and bring the outside temperature extremes within the comfort range.

Outgoing, longwave "heat" radiation has been used to cool buildings and even to produce ice in desert areas when air temperatures are in the low forties. In the 1960's Harold Hay built and tested a naturally cooled and heated structure. The results of the year-long test are displayed in the temperature distribution figure.

A number of houses have been built in several different climates demonstrating the validity of the concept of natural cooling. Natural cooling requires blocking of the summertime solar heat which insures beneficial heat loss transfers through radiant exchange with the cold north sky and evaporation. As part of the project, an experiment has been done which demonstrates that very similar cooling results can be achieved in Indio using a much simpler system, developed by Living Systems and called the "cool pool".



COOL POOL HOUSE

Cooling Mode Operation
Water Pond flooded at start of cooling season and insulating panels inside the house are removed. Design of structure is such as no direct sun hits the water. Radiant loss to cool northsky and evaporative cooling occur throughout the day keeping the water at 80°F or less.

Both of the natural cooling systems hold the promise of freeing those who utilize them from the noise of an air conditioner. The benefits of natural heating and cooling extend far beyond the simple bounds of energy conservation. A naturally heated and cooled house doesn't suffer from vibration or noise from mechanical heating or cooling machinery. Smaller daily variation in interior wall and window temperatures increases perceived comfort. And finally, the homeowner can sleep secure in the knowledge that despite rising fuel prices or power failures, the house will remain economical and comfortable.

II.2 THE INDIO BUILDING CLIMATE: DESIGN STRATEGIES. The Indio climate is typical of the Coachella Valley and is characteristic of the hot-dry, low desert. At first glance the climate might seem so extreme that natural heating and cooling would be impossible, yet such is not the case. The climate can be made very pleasant through the use of proper natural heating and cooling strategies with little or no energy input. Short of this, many changes can be made in current designs to minimize energy use through climatic design which are economically attractive.

The average annual temperature in Indio is an almost ideal 74 degrees; and at twelve feet below the surface of the soil, comfortable temperatures are maintained all year. Indio is also blessed with abundant solar radiation in winter and a clear, cool night sky in the summer.

The most obvious constraint is the hot summer period with very hot days and warm nights. The strong, dusty north winds of spring and fall should also be dealt with by judicious use of shelter belts on the north edge of town. The final consideration is the short, "cool" winter with occasional "cold" spells. Despite the low number of degree days, there is a definite need for "solar" exposure during the winter. In part, this heating is needed because of man's adaptation to the desert heat, requiring some heating when temperatures drop below 75 degrees in the winter.

Even though the Indio climate is generally mild, considerable energy can be saved during the winter season by proper design and use of the sun's energy. Therefore, it is important even in a short winter season which occurs in Indio to give proper credit for south-facing solar glazing. Solar glazing is any clear glazing which faces to within 22½ degrees of due south and receives direct sun for the middle five hours of December 21. In any area as sunny and mild as Indio, a very small amount of properly designed solar glazing backed with thermal mass is all that is needed for a dwelling to be substantially solar heated.

The summer season is of such great duration that there are two distinct types of hot weather. In the months of April, May, and October, the average high is 91 degrees with an average low of 60 degrees, allowing for natural cooling with night time ventilation. The months of June, July, August, and September are intensely hot with only a few hours which have outside temperatures below 80 degrees. The average high for these months is 104 degrees, with an average low of 74 degrees.

There are four basic parts of a house which most directly affect summer heat gain. These are: external color, thermal resistance, window orientation, and thermal mass. The radiant gain through windows can easily dominate a dwelling unit's thermal performance if it is unshaded or of such great extent that even shading the windows from direct sun, which still allows 20% of the radiant heat in as indirect or diffuse radiant gains, yields unsatisfactory performance. Due to the severity of the summer, all windows should be shaded; and it would be best to shutter all except the smallest windows.

These principles can be applied to both new buildings and existing structures. New buildings are easiest to design for low energy use because the structure can be properly oriented and designed with energy conservation in mind. Existing structures can be improved, yet some changes might be needed to dramatically reduce energy use.

Design Days. To encourage good design with an economically optimal level of thermal performance, the concept of the design day has been established. After a careful analysis of the climate of Indio and the area's energy use patterns, the need for a winter and a summer design day was apparent.

The winter design day is set to have an average daytime temperature of 54 degrees which is also the average temperature for the month of January. The sun's path through the sky is set as being that which occurs on December 21. There are 432 degree hours in the day. Degree hours are figured by multiplying the difference between the desired inside temperature (72 degrees) and the average outside temperature (54 degrees) by the hours and the day. Credit for the amount of sunshine available is given by averaging the percent possible sunshine data for the area over the three month heating season of December, January, and February. This parameter is termed the Solar Climatic Variable and is 86% for Indio, reflecting the large number of clear winter days which occur. Due to the warm daytime temperature which is prevalent even in "cold" weather, 1500 BTU/sq. ft. storage is required for each square foot of solar glazing to prevent overheating.

The summer design day is a warmer than average day with the sun's path being that which occurs on September 21. Shading is of primary importance for adequate thermal performance. In order to insure proper shading, five check hours are set. They are as follows:

Date	Time	Altitude	Azimuth
Sept. 21	0800	25.1	S73.0E
	1000	38.7	S39.1E
	1200	58.0	S 0.0
	1400	38.7	S39.1W
	1600	25.1	S73.0W

Heat calculations require an hour by hour analysis in order to account for the thermal lag effect present in all opaque parts of the building envelope. In addition, the designer's intuition is educated by knowing the hour by hour temperature structure of the design day. Because of these points, the temperature at each hour of the day is specified.

The temperature structure for the day is as tabulated below:

Time	Temp	Time	Temp	Time	Temp
0100	86	0900	93	1700	112
0200	84	1000	99	1800	109
0300	82	1100	102	1900	105
0400	81	1200	106	2000	101
0500	80	1300	110	2100	97
0600	78	1400	112	2200	93
0700	80	1500	114	2300	90
0800	86	1600	114	2400	88

II. 3 NEW BUILDINGS. House units are more standardized than commercial and industrial buildings, and occupants commonly have little control over design. For this reason, the City Energy Conservation Building Code deals with new residential construction. The principles can also be applied to commercial or industrial structures.

III. ENVIRONMENTAL REVIEW AND ENERGY CONSERVATION

Environmental impact reporting requires that consideration be given to energy conservation. Particular emphasis on avoiding or reducing inefficient, wasteful, or unnecessary consumption of energy is required by the California Environmental Quality Act (CEQA) under Appendix F of said Act. The City of Indio has developed a checklist for energy conservation and it is included as a separate part of this section.

Considerations of energy conservation should be on a project by project basis with the following energy conservation measures indicating energy consumption in transportation, building design, land use, and landscaping. Noted below are those features which would mitigate unnecessary and wasteful energy consumption.

Transportation. Basically, this section would deal with the accessibility of transit facilities, if a proposed development would be constructed within an existing transportation system and/or within a public transportation system. Whether or not the development would be a hardship to public facilities and manpower is an issue that has to be resolved by CEQA.

Building Design. Perhaps the greatest energy conservation feature of the program, building design includes roof and wall color, insulation, ventilation, shading, thermal mass, material and life cycle costs, and lighting standards. Close attention and detail to these facets of a building could reduce energy consumption by at least 20%.

Land Use. Land use includes the street design and lot layout of a proposed subdivision, and will have as much to do with energy conservation as the building performance standards. Lot orientation and proper street design include a predominate pattern of east-west streets so that north-south lots will predominate. In the event that north-south streets are necessary, then wider lots to provide proper building orientation will be a necessary condition to achieve energy conservation.

Landscaping. Proper landscaping for shading of streets, parking lots and lot area could reduce temperatures by as much as 10 degrees on the microclimate of the buildings and surrounding area.

The purpose of the environmental section is to not only facilitate and reduce energy consumption, but to assure that consideration of energy is included in the earliest stages of subdivision and building design. A checklist, to facilitate this concern, is presented in this section. Subject checklist enumerates the standards as listed above and provides mitigation measures to review the compliance and conformance to energy conservation methods.

Environmental Impact Report Considerations.

PROJECT DESCRIPTION

- Identify any energy consuming equipment and design features.
- Identify initial and life cycle energy costs.

SETTING

- Inventory of existing energy sources by fuel type.
- Inventory of existing energy uses by fuel type.
- Identify climatic factors which will affect project energy use.
- Review relationship of proposed development and its relationship to schools, shopping centers.

ENVIRONMENTAL IMPACTS

- Energy requirements and efficiencies by amount and fuel type and initial vs. life cycle costs for construction, operation and maintenance and/or removal:

  Buildings
  Streets and roads
  Utilities, water, sewer
  Street lights
  Transportation

- Effects on energy source - local and regional.
- Effects on energy - peak hourly and/or seasonal demands.

UNAVOIDABLE ADVERSE IMPACT

- Net energy demand.

MITIGATION MEASURES

- Project design.

  Site preparation.
  Shorten length and width of streets, paved surfaces.
  Lot and building orientation, shading of roof and windows, insulation, solar energy retrofit.
  Encourage energy conservation in transportation.

ALTERNATIVES TO THE PROJECT

- Cluster.
- Planned Unit Development.
- No project.

SHORT TERM GAINS VS. LONG TERM IMPACTS

- Effects of rising fuel costs.
- Short term energy benefits as opposed to long term energy sources.

IRREVERSIBLE COMMITMENT OF RESOURCES

- Use of non-renewable research.

GROWTH INDUCEMENT

- Effect on energy sources and distribution systems.

A Checklist of Energy Conservation.

SITE DESIGN	YES	NO
1. Use deciduous trees for their summer sun shading effects and windbreak.	___	___
2. Cover exterior walls and/or roof with earth and planting to reduce heat transmission and solar gain.	___	___
3. Shade walls and paved areas adjacent to building to reduce indoor and outdoor temperatures.	___	___
4. Reduce paved areas.	___	___
5. Use ponds, water fountains, to reduce ambient outdoor air temperatures.	___	___
6. Locate buildings to assure natural ventilation and cooling.	___	___

SITE DESIGN	YES	NO
7. Select site that allows for orientation of building to minimize yearly energy consumption.	___	___
8. Select site that allows occupants to use public transport systems.	___	___
9. Provide majority east-west streets.	___	___
10. Provide for a majority of north-south lots.	___	___
11. Change project concepts, i.e. cluster, zero lot line, planned unit development.	___	___
12. Street design including: widths, length, etc.	___	___
BUILDING DESIGN		
1. Construct building with minimum exposed surface area to minimize heat transmission.	___	___
2. Minimum glazing on east, west and south wall to reduce cooling load.	___	___
3. Buildings must provide self-shading by eaves, walls, other features.	___	___
4. Insulate walls and roofs.	___	___
5. Provide shading for glazing on east, west, and south walls.	___	___
6. Finish walls and roofs with a light colored surface.	___	___
7. Reduce heat transmissions through roof by:		
a. Insulation.	___	___
b. Reflective surfaces.	___	___
c. Cool pool.	___	___
8. Reduce infiltration by:		
a. Weatherstrip around doors, windows, etc.	___	___
b. Locate ventilation louvers on downwind side.	___	___
9. Consider the amount of energy required for operation and maintenance on a life-cycle energy usage.	___	___
10. Consider insulation type which will optimize the thermal resistance of the wall or roof, for example R-19 walls, R-25 ceiling.	___	___
11. Face roofs to the south for greatest heat gain benefit in the wintertime and retrofit for solar energy.	___	___

BUILDING DESIGN	YES	NO
12. To reduce heat loss from windows, consider one or more of the following:		
a. Use minimum ratio of window area to wall area.	___	___
b. Allow direct sun on windows November through March.	___	___
c. Use operable thermal shutters which decrease the composite U value to 0.1.	___	___
13. To reduce heat gains through windows, consider the following:		
a. Use minimum ratio of window area to wall area.	___	___
b. Double glazing.	___	___
c. Double reflective glazing.	___	___
d. Shade windows from direct sun April through October.	___	___
14. To take advantage of natural daylight within the building and reduce electrical energy consumption, consider the following:		
a. Locate windows high in wall to increase reflection from ceiling.	___	___
b. Provide exterior shades that eliminate direct sunlight, but reflect light into occupied space.	___	___
15. Lighting standards.	___	___
16. Window orientation.	___	___
17. Water heating methods.	___	___
18. Coordinate with life cycle energy use list.	___	___
19. Coordinate with material energy list.	___	___
20. Discuss the energy use and conservation measures used in:		
a. Transportation.	___	___
b. Traffic circulation (bike, pedestrian, bus, auto, emergency vehicle).	___	___
c. Transit accessibility.	___	___
d. Support facilities (bus shelters to keep sun off, bike racks, etc.)	___	___
21. Land Use:		
a. Street design and layout.	___	___
b. Lot size and orientation.	___	___
c. Density.	___	___
22. Landscaping:		
a. Street trees, parking lot trees, area landscaping (diagrams).	___	___
b. Windbreaks, relation to blow sand.	___	___

PLANNING FOR ENERGY CONSERVATION

IV. PLANNING FOR ENERGY CONSERVATION

IV.1 LAND USE PLANNING.

Present and future planning indicates that the City of Indio will be dominated by a low density suburban development. The City has experienced rapid growth and development during the last fifteen years, which, coincidentally, is the same period in which building design and construction, heating and cooling appliances have shown a distinct trend toward energy inefficiency.

Growth in the next decade is expected to take place by completion of approved projects, in filling and new development proposals. Future development is planned for areas contiguous to existing development and for areas already partially developed, and this thought is carried throughout the Land Use Element of the General Plan. Energy conservation opportunities which can substantially reduce energy consumption and be a positive commitment to conservation can be expressed and realized through project and building design. City policy changes or suggested ordinances are attached to the appendix section of this report and have been designed to reduce energy consumption in Indio's neighborhoods.

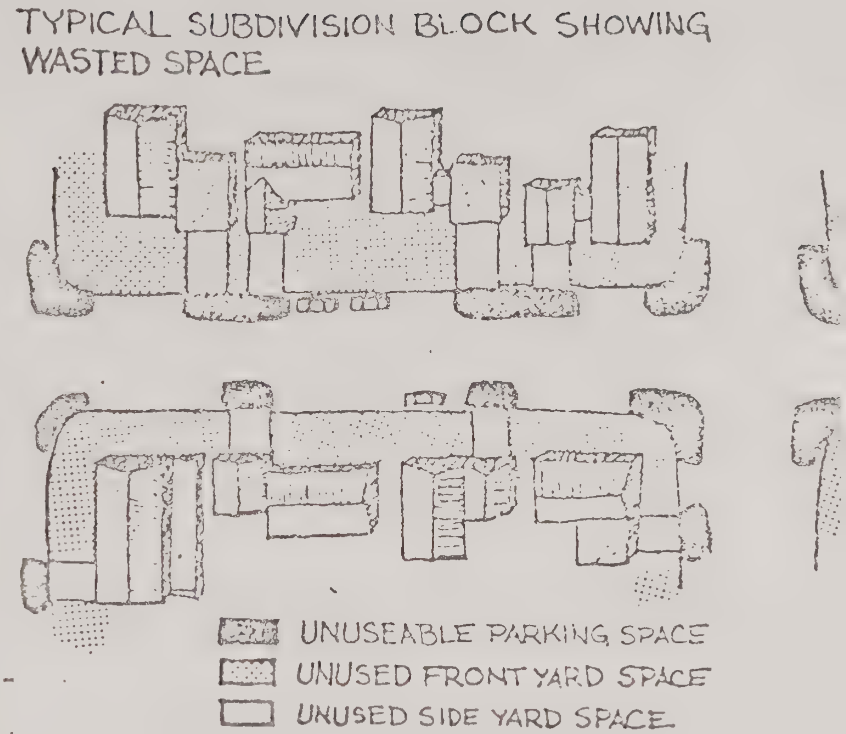


FIGURE 1

Indio's unique climate could allow for the implementation of solar heating and cooling technology that is presently too expensive for the average homeowner to install or maintain or buy already-constructed on a new home. However, the potential for the development of products specializing in these techniques at a reduced cost is imminent. Preparation for retrofitting of existing homes when this new industry comes of age must be made now. Insuring that future subdivisions will have a view of the sun in the winter for solar space and water heating is a preparatory step for energy conservation and a necessary precaution for future energy technologies and an example of a physical technique that encourages energy conservation.

It is anticipated that the incorporation of the above will be a very good start in solar energy technologies. Note also that Legislation recently approved by the State Legislature does allow for local municipalities to pass and approve ordinances related to design and site orientation for future retrofits to solar energy.

A second proposal is to provide greater flexibility to the existing zoning ordinance by reviewing, for energy conservation purposes, the existing regulations by adding a few new policies for energy conservation purposes. These new regulations and policies will allow more efficient use of the land and create an adaptability for the designer and decision-maker for siting of buildings on lots in order to take advantage of solar orientation for both solar heating and clustering for buildings. The changes revolve around changes in building setback, propose the establishment of a new, smaller lot size and deregulate fence setbacks. The following is a summary of the proposed changes. Note that resolutions and ordinances pertaining to these changes are in the Appendix section of this report:

- Reduction of the front yard in low density multi-family (R-2), multi-family (R-3), and residential office (R-0) zones to 4 feet and 3 feet respectively from 15 feet.

- Changing zero lot lines to a permitted use and allowance in single family (R-1), low density multi-family (R-2), multi-family (R-3), and residential-office (R-0) zones.

- Reduction of minimum lot size and lot width in single family (R-1) zones and an addition of an R-1-4 (3,000 square feet) and R-1-2 (2,000 square feet), with appropriate front yard, side yard and rear yard requirements.

- Deletion of side and rear yard requirement in residential office (R-0) zone.

- Reduction in rear yard requirements of single family R-1-6 to 6 feet from 10 feet.

- Reduction of carport and garage setback from 20 feet to 3 feet in R-1-6 zone.

- Reduction of front yard to 3 feet in R-1-6 zone.

- Allowance of a 7 foot high fence in front yard.

- Reduction in lot widths in low density multi-family (R-2) and multi-family (R-3) zones from 75 feet and 70 feet respectively to 30 feet.

- Reduction of side yard requirement in multi-family (R-3) and low density multi-family (R-2) zones by 1 foot.

- Allowance of zero lot line development as a permitted use in side and rear yards in multi-family (R-3) and single family (R-1) zones.

- Reduction of minimum lot size in low density multi-family (R-2) zone from 8,000 square feet to 3,000 square feet and residential office (R-0) zone from 7,000 square feet to 3,000 square feet.

- Reduction of minimum house size to: R-1-4 to 700 square feet; R-1-2 to 600 square feet.

- Reduction of lot width in R-2 zone to 30 feet from 75 feet.

- Minimum setback for face of garage or carport shall be the same as for front yard in R-1 zones.

- Reduction in lot size of residential office (R-0) zone from 7,000 square feet to 3,000 square feet, lot width from 75 feet to 30 feet, front yard from 15 feet to 3 feet.

- Addition to residential office (R-0) zone that nondwelling units may be built to side or rear property line.

Presented above are alternatives to the present zoning regulations. The present regulations were developed and adopted in an era of cheap and presumed abundance of natural resources. The proposed regulations represent, if adopted, methods to promote energy conservation while still maintaining and providing for the following needs:

Social Needs. Spatial arrangements of buildings should accommodate peoples' need for privacy as well as neighborliness, need for security as well as the desire to relate to the community and the desirability to survey public areas versus the need for privacy from persons looking into private spaces.

Aesthetic. Aesthetic needs in terms of an identifiable location, openness, and vitality within the space.

Presented in Figure 2 is an example of a typical subdivision with builtin unuseable spaces. These unuseable spaces may be eliminated and/or significantly reduced with the adoption of the proposed policies.

The consultant has also proposed to deregulate fence heights in the front yard. Present regulations allow only a 3.5 foot high fence in the front yard; the consultant has recommended a seven (7) foot high fence in the front yard. The consultant has based his recommendations on the following:

- Regulation of personal property and behavior is becoming increasingly burdensome.

- Increased use of developed land can reduce demands on resources and energy by reducing conversion of agricultural land and reducing travel distance and time. Fences can provide privacy to allow better natural ventilation, solar heating in winter through south windows, and more intensive use of property.

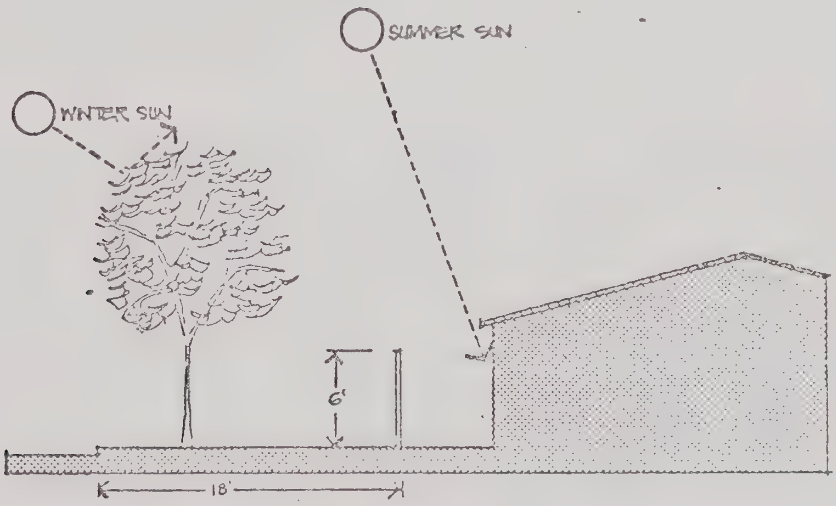
- Private garden front courtyards can, with good design, provide a cool micro-climate entryway which helps keep the house cooler.

- Complaints over untidy lawns can be easily eliminated if front fences are allowed.

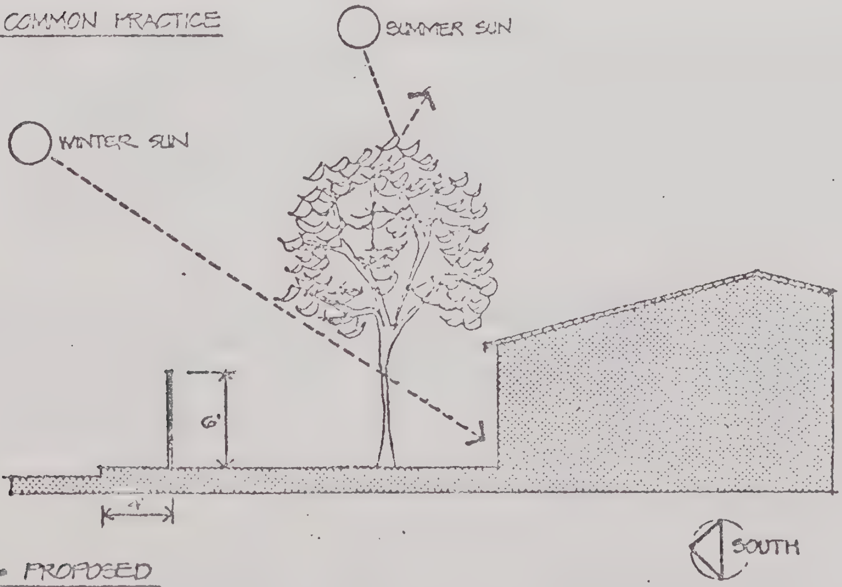
The deregulation of fences will still provide for and maintain the original purposes of the front yard space which are:

- Provision of a spatial barrier between the public space and the private space.
- A means of upgrading status.
- A territory in which to express individuality.
- A place in which to make or expand social contacts with neighbors.

Subject ordinance change is indicated in Figure 3.

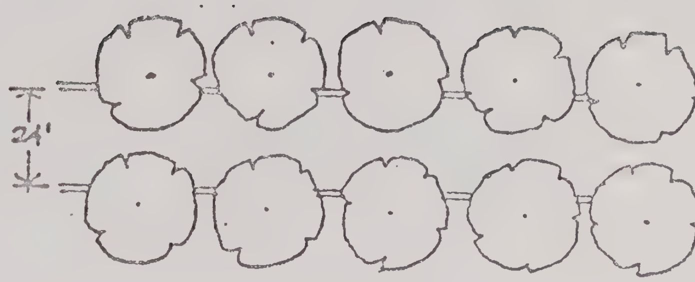


FENCES • COMMON PRACTICE



FENCES • PROPOSED

V. STREET DESIGN FOR ENERGY CONSERVATION



V.1 INTRODUCTION. Land allocations for a transportation system are a necessary part of energy conservation. The careful design of streets and parking facilities can significantly reduce energy use and the cost of housing; yet, the energy investment in streets for construction and maintenance is only one part of the energy cost. Construction and maintenance energy includes: heavy equipment operation; the asphalt used in streets; the energy used to make cement for sidewalks, etc. Maintenance cost includes repairs and patching, street sweeping, striping, etc. These energy costs are only the top of the iceberg. Wide streets increase sprawl, and the decreasing density fosters a greater reliance on the automobile which is both energy and money intensive.

However, the greatest energy cost probably results from the adverse effect of streets on the microclimate during the summer. On unshaded streets the surface temperature of asphalt on a 100 degree day can reach 140 degrees. This increase in temperature can increase energy use in several ways. First, this hot surface can increase the maximum air temperature by as much as 10 degrees F, thereby increasing the load on the home air conditioners. A 10 degree difference in air temperature may not sound like much; but if the difference between outside (100 degrees F) and inside (75 degrees F) air would be 25 degrees without wide streets but is 35 degrees because of them, then the 10 degree increase represents a 40% increase in thermal load on structures and a 50% to 60% increase in energy used (40% plus efficiency loss). The use of narrower streets can make full shading by trees easier and can further reduce temperature.

The increased air temperature also contributes to human discomfort, but the surface temperature is even more crucial. Air temperature and radiation are about equal in human comfort. Thus, on a 100 degree day on a 90 degree surface (grass), we might feel only slightly warm; yet, in a street with surface temperature of 140 degrees, we would be very uncomfortable. This discourages cyclists and pedestrians and increases the use of autos with air conditioners, greatly increasing energy use.

Streets also increase night temperature because they have stored a great deal of energy during the day and re-radiate it at night. This increases the use of air conditioners at night when natural ventilation or an evaporative cooler would otherwise suffice.

The elimination of most street parking in new development - this is often done on private streets and reduces street width by as much as 16 feet. Street parking has often been considered a "sacred" item, but it is most often little used and can be dispensed with in favor of considerably reduced, localized, shaded parking and use of driveways.

A second saving can be made on local streets with little traffic by eliminating sidewalks on one or both sides, or using stepping stones. The careful design of streets to reduce traffic should allow mixed use of streets without difficulty. The reduction in width and mixing traffic increases "perceived impedence" and results in slower speeds with more careful driving. Changing local street design to largely one-way can also be very helpful in reducing street width without increasing hazards.

Speed limits should be 15 miles per hour for access, 25 miles per hour for collector, and 35 miles per hour for arterial.

Several objections can be raised to this decrease in road width. First, fire safety is a real concern. However, by maintaining the same travel way (no parking) this should be minimized. Home smoke detectors (now required by code) will also reduce hazards. Careful design of fire lane and hydrant placement can further increase safety. The savings from street reduction will offset higher cost of hydrant installation.

A second objection concerns provision of parking spaces on the street. This is simply a change in lifestyles as there is no particular reason for street parking. A survey in Indio indicated that 20% of the cars are compact and 20% are subcompacts. As car sizes continue to drop, parking might be added to what are now considered narrow streets.

Safety concerns are the final issue. Experience with narrow streets in Sacramento, Richmond, and other communities does not indicate problems; but little research has been done. It is known that roadside parking is responsible for 12% of accidents in the U.S. Research in England has shown that a narrow street can carry more traffic than a wide street while maintaining the same level of pedestrian safety. A very clear demarcation between street types is also helpful.

The savings possible with narrower streets have been touched upon, but a more detailed accounting should be educational. A street with 8 houses on 50 foot lots will demonstrate the issues involved. The standard 40 foot street will be compared with the 24 foot private drive. These are rather crude calculations; but the data, as shown in Table __, is not readily available to make better estimates. They should be in the right ballpark even if they are not "right."

TABLE

The Cost of Wide Streets

	CASE 1	CASE 2
	40 feet	24 feet
Land Use in Streets	9,600 sq. ft.	4,800 sq. ft.
Percentage of Lot Area	24%	12%
Land Cost - $1/sq. ft.	$ 9,600.00	$ 4,800.00
Construction Cost		
Street $ .50 sq. ft.	$ 4,200.00	$ 2,400.00
Curb $ 8.00 ln. ft.	$ 3,200.00	$ 3,200.00
Sidewalk $ 8.00 ln. ft.	$ 3,200.00	$ 0.00
TOTAL	$10,400.00	$ 5,600.00

	CASE 1	CASE 2
Temperature 100^{0} day	110^{0}	100^{0}
Air Conditioning Efficiency	x + 15%	x
Internal Temperature	75^{0}	75^{0}
ΔT^{0}	35^{0}	25^{0}
Average Trip/Week (Miles)		
Auto	60	56 @ 13¢/mi
Bike	0	4 @ 3¢/mi

Assume that the interest rate possible on investment is nine percent, the interest rate on a construction loan is nine percent, and a typical air conditioning bill is $300/year.

Annual Unit Cost for Wider Streets

Air Conditioner increase cost	$150	(300 x 50% = 150)
Interest on construction cost	$ 54	($10,400 - $5,600/8 x 9%)
Value of land lost	$ 54	($4,800/8 x 9%)
Auto v/s Bike	$ 20	(200 mi/yr. x 10¢ mi)
Maintenance	$ 20	$\left(\frac{300,000}{7,000} \times \frac{4800}{9600}\right)$
TOTAL	$298 .	

Thus, if streets were kept at 24 feet, every homeowner would pay about $300 less every year. If this $300 were applied to a loan to improve his house ($3,000), then further savings could be realized.

The following street widths are suggested for energy conservation.

Street Design for Energy Conservation

Local Streets: Based on Units Served*

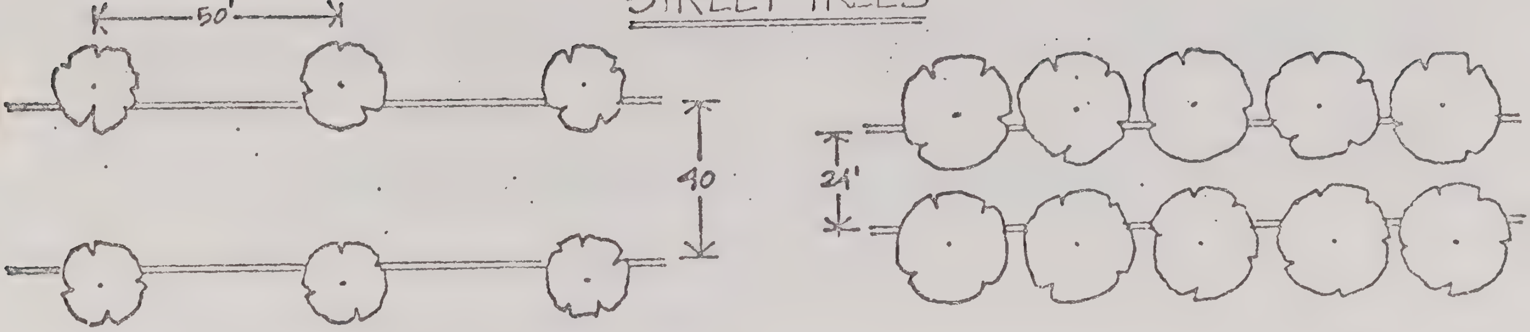
	Width	Units Served	One/Two Way	Street Parking	Sep. Bike Paths	Maximum Length
Access A	16'	<20	1 or 2	No	No	300'
Modified	+7'			Yes, one side		
Access B-1	24'	20-40	2	No	No	600'
Access B-2	20'	20-40	1	No	No	300'
Modified	+7'			Yes, one side		
Access C-1	24'	>40	2	No	Yes	600'
Access C-2	20'	>40	1	No	Yes	300'
Modified	+7'			Yes, one side	No	

**See Appendix for Street Design.*

Unfortunately, new streets will make up a very small portion of the total street mileage in Indio. Retrofitting existing streets should be possible in many cases; for example, center planter or alternate parking and planting areas would be possible in meeting the standards proposed for new streets.

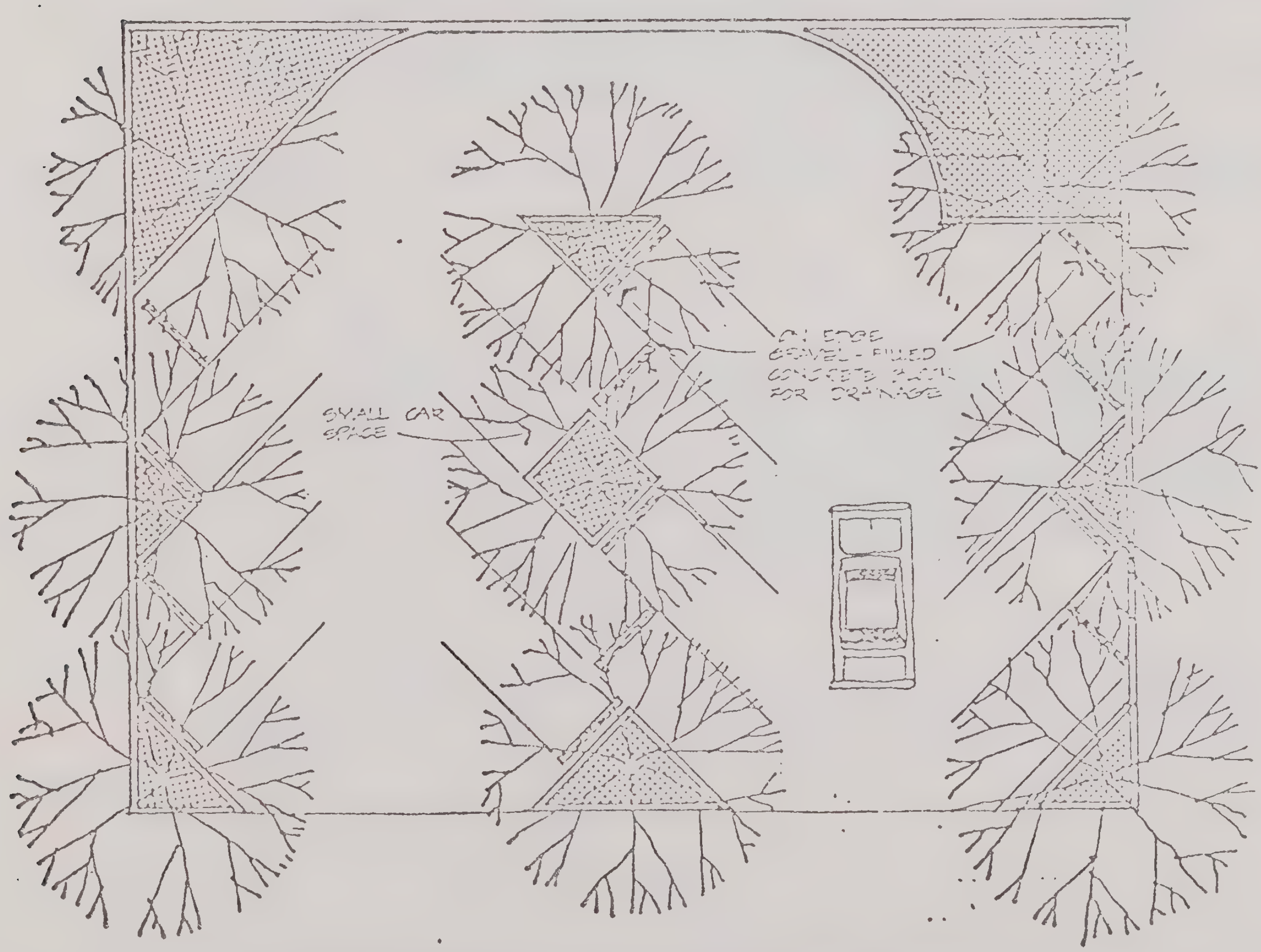
V.2 LANDSCAPING. Landscaping of streets and parking lots also plays a dominant role in the feeling of livability and quality of a community. Proper landscaping can reduce adverse climatic conditions and reduce energy use for cooling. Shown below is an illustration of this concept as it relates to present City standards:

STREET TREES



NORTH INDIO
- SMALL TREES FAR APART
- WIDE PAVEMENT
- LITTLE SHADE
- VERY HOT

PROPOSED LOCAL STREET
- LARGE TREES CLOSELY SPACED
- NARROW PAVEMENT
- FULL SHADE
- COMFORTABLY COOL



A WELL - SHADED PARKING LOT

To accomplish the above, the minimum standards for shading of parking lots, streets, and new commercial development should develop and follow the criteria listed below:

- Design tree planting so that a minimum 50% of the parking area will be shaded within fifty-one (51) years of the planting.

- Cast moderate to dense shade in summer.

- Long-lived, over 60 years.

- Does well in an urban environment.
    - Pollution tolerant.
    - Tolerant of direct heat and reflected heat.

- Little maintenance.
    - Mechanically strong.
    - Insect and disease resistant.
    - Requires little pruning.
    - Able to survive one year with no irrigation after establishment.
    - City staff should plan and budget retrofitting of City-operated parking lots and tree planting of existing public streets.
    - Landscape plantings must be designed in commercial areas to maximize shading of buildings and paved areas.

The above concepts are presented by resolution and ordinance in the Appendix section of this report.

V.3 TRANSPORTATION.

Bikeway Plan and Design. The energy efficiency of bicycles and City efforts to encourage their use and provide for them in the traffic circulation system is an important consideration for energy conservation.* The Indio climate, although not perfect for bicycling, has many days when it would be comfortable and practical. For this reason we have prepared a package of material on bicycle planning and design for use in preparing a bikeway plan. The material is outlined below outlining the steps we feel should be considered.

1. Review bikeway planning package.

2. Establish bikeway planning team: Planning Department, Public Works, Parks and Recreation, School staff, active cyclists, are suggested members.

3. Develop goals and objectives.

---

* *Bicycles are efficient, clean, quiet, aesthetic, durable, inexpensive to buy and operate, space efficient, economical to build for, available to more people than most transit modes, and healthy. In addition, they are easy to interface with other modes of mass transit and offer the most time efficient transportation to cities up to 100,000 people. They provide excellent transportation for distances of under 12 miles.*

4. Inventory existing conditions: street surface, bicycle accidents, easements.

5. Estimate demand: street checks, schools, shopping centers, parks, etc.

6. Identify constraints: access problems, weather, lack of facilities, etc.

7. Develop planning and design standards.

8. Prepare draft: Bike Plan - routes, design, alternatives, priorities, funding search, etc.

9. Draft review by citizens.

10. Prepare final plan, commit funding.

11. Implement plan.

12. Monitor performance, modify if needed.

13. Periodic review and update.

For your information and review, below are summaries of the design and planning criteria.

Planning Criteria. Planning includes the design criteria listed and the following additional criteria. The plan should be:

- Flexible and non-static, subject to yearly review.
- Realistic and implementable.
- For both short and long term.
- Environmentally oriented to minimize potential impact on physical and social environment.

Design Criteria. Given the projected and desired use of the Indio Bikeway System, the following design criteria have been developed. The bikeway should:

- Link Indio neighborhoods, provide safe access to Palm Springs, Coachella, and Palm Desert.
- Minimize adverse impact on both natural and social environments.
- Attempt to meet the needs of all cyclists, young and old, tall and short, beginning and experienced; including parking, restrooms, water, and picnicking.

- Provide maximum satisfaction and enjoyment for riders, including interesting, wandering paths with ups and downs and turns.

- Be safe, particularly at crossings or intersections with roads, or where the system utilizes a striped lane along a regular roadway.

- Be durable, economical, and easily maintained.

- Prevent use by motorcyclists.

- Separate bicycle, horse, and foot traffic.

A detailed study, prepared by Living Systems, of the above concepts, is available at the Department of Planning & Development.

Pedestrian Plan. Also suggested is that the Planning & Development staff be directed to prepare a Pedestrian Plan for the City of Indio. Subject plan should include: recommendations for routing, shading, easement acquisition, and any other criteria deemed necessary and supportive of energy conservation and pedestrians.

VI. CITY ADMINISTRATION

The City itself uses considerable energy for maintenance of City buildings, fleet, and general operations. The City can provide very visible leadership by implementing energy conservation measures. At the same time the City will save considerable money. Operation of the City Hall and the City fleet can both be modified to increase efficiency and reduce cost and energy use.

The vehicles used by the City for police, administrative, and utility work can be chosen to conserve energy and save money. The consideration of life cycle cost is essential for sound purchasing. Life cycle cost includes: purchase price, fuel consumption, lifetime parts and maintenance and resale value.

The choice of police patrol vehicles is most important because they are driven more total miles every year. However, other vehicles may offer even greater savings over their life because they need not meet such strict requirements for performance.

Indio City Fleet. The operation of the Indio City fleet is being made more efficient through the purchase of compact vehicles. The magnitude of potential savings by the use of subcompact and compact vehicles is probably on the order of $10,000.00 per year at current gas prices. If, as seems likely, prices increase this figure would increase proportionately.

The choice of vehicles should include review of reports on lifecycle costs, performance, and reliability. The use of compact trucks is increasing and will provide further savings. Where possible, total miles traveled should be reduced.

Technical Advisory Committee. Also recommended as a part of City function is a permanent committee which would review energy issues and a monitoring of the City's energy program. Principally, the goals of this committee would be:

To monitor Federal and State energy conservation activities and to advise the City Council on matters of local interest and impact.

To monitor and advise on City energy conservation programs, including: planning policies and regulations; building codes; local government operations (e.g. building operations, equipment operations, recycling programs); encouraging citizen participation in implementing energy conservation activities.

The composition of the committee should be a balance between groups and interests in the energy question. Technical assistance would have to be a part of successful committee operations; thus, a commitment of staff would be a minimum prerequisite.

Suggested committee composition:

Voting members:

1. One Council member.
2. One Planning Commissioner.
3. One member representing Imperial Irrigation District.
4. One member representing building design profession.
5. One member representing major business interest.
6. One member representing building contractors.
7. One member representing interested citizens.

Non-Voting Members:

1. City Manager
2. Director of Public Works.
3. Director of Planning & Development - Secretary to the Committee.

The committee would meet as needed; however, monthly meetings during part of the year should be anticipated.

VII. LIFESTYLE

Considerable savings can be realized without any change in lifestyle. More efficient cars, refrigerators, appliances, and air conditioners can be made at competitive prices and result in very real savings to the homeowner and society. The State Energy Commission has shown that it costs only $1,000 to free a kilowatt hour of generating capacity by adding more efficient refrigerators, yet it costs $2 - $3,000 to add a new kilowatt hour of generating capacity. Similar savings could be realized by increasing the efficiency of all of our energy uses.

Yet, if we wish to maximize energy efficiency, we will have to make some changes in our lifestyle. An obvious example includes drying clothes outside instead of using an electrical clothes dryer. We can also walk and ride a bicycle more, rather than driving. And we can choose goods carefully, buying those with less packing, and recycling all possible materials.

All of these changes will help our society survive and prosper despite rapidly increasing energy prices. European countries with similar or higher standards of living are now using only one-half as much energy as the United States and are actively pursuing zero energy growth. We should do no less.

Three proposals are presented to encourage energy efficient lifestyles. The first ordinance would require swimming pools to be heated using the sun. The second would require new multi-family developments to provide clotheslines. And the final recommendation is in the form of a resolution which asks the State legislature to pass legislation requiring energy efficiency labeling on all appliances sold in California.

Because of the rising costs of energy methods and means to limit or curtail the unnecessary consumption of energy, it is proposed that an ordinance prohibiting restrictive covenants or regulations that ban the use of clotheslines and further, require that clotheslines be required for all multi-family dwellings. Noted below is evidence of the excessive amounts of energy used by as and electric dryers.

TABLE : COST/ENERGY

Option	Cost/Use	Energy BTU
Gas dryer, electric pilot	$ 8.9	19,000
Electric dryer	$13.3	46,000
Clotheslines	$ 1.2	600

TABLE : ANNUAL ENERGY COST: TWO LOADS PER WEEK

Gas dryer, electric pilot	2 million BTU's
Electric dryer	4.7 million BTU's
Clotheslines	62 thousand BTU's

BUILDING FOR ENERGY CONSERVATION

RESOLUTION NO. 2940

A RESOLUTION OF THE CITY COUNCIL OF THE CITY OF INDIO, CALIFORNIA, ADOPTING PROCEDURES FOR COMPLIANCE WITH THE ENERGY CONSERVATION PERFORMANCE STANDARDS FOR RESIDENTIAL CONSTRUCTION WITHIN THE CITY OF INDIO.

WHEREAS, the City of Indio has, by ordinance, established certain energy conservation performance standards for new residential construction within the City of Indio; and

WHEREAS, the ordinance which establishes energy conservation performance standards provides that standard methods for determining compliance of proposed buildings shall be established by resolution.

NOW, THEREFORE, BE IT RESOLVED BY THE CITY COUNCIL OF THE CITY OF INDIO, CALIFORNIA, AS FOLLOWS:

I.
APPLICATION

Compliance with the energy conservation performance standards established by the City of Indio shall be determined by reference to the provisions of this resolution and any amendments thereto.

II
DEFINITIONS

For purposes of this resolution and the energy conservation performance standards ordinance of the City, the following words and phrases shall have the meanings respectively ascribed to them by this section:

A. R Values. (1/U=R) Thermal Resistance (R) is the measure of the resistance of a material or building component to the passage of heat. The units of measurement are: (Hours) (Degrees Fahrenheit) (Square Feet)/BTU. The resistance value (R) of mass-type insulations shall not include any value for reflective facing. (Note: For reflective foil insulation, use ASHRAE procedures only. Calculate both the winter and summer composite resistance value and use whichever is less).

B. Composite Thermal Resistance (R_t) is the sum of each of the resistance values of the parts of an assembly of materials which together form an external skin element of the structure. For example, a commonly used wall is one which has an interior air film, one-half (1/2) inch thick plaster board, six (6) inch batt insulation, stucco, and finally, an exterior air film, all of which have R values which are added together to derive the R_t value for the wall element.

C. Orientation. The compass directions are designed as follows when the attached tables are used:

North	337.5 degrees - 022.5 degrees
Northeast	022.5 degrees - 067.5 degrees
East	067.5 degrees - 112.5 degrees
Southeast	112.5 degrees - 157.5 degrees
South	157.5 degrees - 202.5 degrees
Southwest	202.5 degrees - 247.5 degrees
West	247.5 degrees - 292.5 degrees
Northwest	292.5 degrees - 337.5 degrees

D. Exterior Surface Area. The area for each dwelling unit of walls, ceilings, suspended floors, glazing, doors, etc. enclosing conditioned spaces and exposed to ambient climatic conditions.

E. Heavy Exterior Building Elements. The walls, suspended floors and/or ceilings which contain a heat storage capacity of 50 BTU's/Day for each square foot of surface area are considered to be heavy (see definition K). Only those materials located on the interior side of insulation materials may be counted. (An eight (8) inch thick lightweight concrete block wall with exterior insulation slightly exceeds these requirements).

F. Color. Surfaces with a Munsell lightness value of 8.0 to 10.0 are to be considered light in color. Surfaces with a Munsell lightness value of 9.0 to 10.0 are to be considered very light in color. The Building Official shall prepare two (2) representative collections of materials and surface covering materials, one with Munsell lightness values greater than 8 and one of materials with Munsell lightness values greater than 9. These collections shall be available for inspection by the public.

G. Glazing. All vertical, horizontal, and tilted translucent or transparent exterior building elements shall be considered glazing with a thermal resistance and daylight transmittance as specified by the manufacturer or as calculated by ASHRAE methods or other reliable references or procedures.

H. Shading Coefficient. The ratio of the solor heat gain through a shading-glazing system to that of an unshaded single-pane of double strength window glass under the same set conditions.

I. Hour's Solar Heat Gain. The amount of energy transmitted through an area of glazing oriented to a particular direction in one (1) hour. The following formula is used for calculation:

HSHG = (SC) (SHGF) (A)
Where:
HSHG = Solar Heat Gain through the glazing for one (1) hour (BUT's/hour)
SC = Shading Coefficient
SHGF = Solar Heat Gain Factor for the hour from attached Table 1 (BTU's/square foot of glazing) using December 21 for winter and September 21 for summer.
A = Area in square feet of glazing exposed to the sun (square feet).

J. Solar Heat Gain Factor. The number of BTU's of solar energy transmitted through one (1) square foot of clear 1/8 inch glass in one (1) hour. This is determined by using the attached Table 1 which applies to 32 degrees north latitude and the eight (8) compass orientations (see definition C).

K. Heat Storage Capacity. The mass located inside the insulated shell of the structure that fluxes through a temperature cycle each day in summer and winter,

absorbing heat during overheated periods and storing it for release during underheated periods. Heat storage capacity shall be estimated by the following procedure:

HS = (WM) (SH) (AT) (SER)

Where:

HS = Heat Storage Capacity (BTU's/Day)

WM = The weight of the materials (lbs) inside the insualted shell of the building to a depth yielding a resistance of R-1, except in the case of slab floors where only the slab itself is credited.

SH = Specific Heat of those materials (BTU's/(lb)(degree f)

AT = Temperature flux; 5 degrees F will be the maximum allowable for calculation purposes, except that lightweight frame construction will be allowed to flux 10 degrees F. (In order to determine the heat or cold available for storage, see Path II, Section 5).

SER = Storage Effectiveness Ratio is based on the climate and has different values for winter and summer. In Indio the SER is 0.5 in winter and 0.39 in summer. As per Section 4.F.2. the summer SER is doubled if an active mechanical ventilation system is installed.

L. Floor Area. Total habitable area of a dwelling unit (expressed in square feet) which is within the exterior face of the insulated shell of the structure and which is heated or cooled.

M. Accepted References. The following are useful and acceptable references:

Handbook of Fundamentals 1972, American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc. (ASHRAE), N.Y., N.Y. 1972.

Architectural Graphic Standards, Charles G. Ramsey and Harold R. Sleeper, John Wiley & Sons, Inc., N.Y., N.Y., Sixth Edition, 1970.

Design with Climate, Victor Olgyay, Princeton University Press, Princeton, New Jersey, 1963.

Sun Angle Calculator, Libbey-Owens-Ford Company, Toledo, Ohio 1975.

Energy Design Manual for Residential Buildings, State of California, Department of Housing and Community Development, Division of Codes and Standards, Sacramento, California, 1975.

III
STANDARD METHODS OF BUILDING PERFORMANCE CALCULATION

A. There are hereby adopted two (2) alternative standard methods of determining compliance with the City of Indio energy conservation performance standards. The two alternative standard methods shall be referred to as Path I and Path II approaches.

B. Structures utilizing either Path I or Path II shall comply with the following:

1. Infiltration. All swinging doors and windows opening to the exterior or to unconditioned areas such as garages shall be fully weatherstripped, gasketed or otherwise treated to limit infiltration. All manufactured windows and sliding glass doors shall meet the air infiltration standards of the 1972 American National Standards Institute (A134.2, A134.3 and A134.4), when tested in accordance with ASTM E 283-73 with a pressure differential of 1.57 lbs./ft.2 and shall be certified and labeled.

2. Loose Fill Insulation. When blown or poured type loose fill insula-

tion is used in attic spaces, the slope of the roof shall be not less than 2 1/2 feet in 12 feet and there shall be at least 30 inches of clear headroom at the roof ridge.("Clear headroom" is defined as the distance from the top of the bottom chord of the truss or ceiling joists to the underside of the roof sheathing). When eave vents are installed, adequate baffling of the vent opening shall be provided to deflect the incoming air above the surface of the material and shall be installed at the soffit on a 45 degree angle. Baffles shall be in place at the time of framing inspection. When loose fill insulation is proposed, the R value of the material required to meet these regulations shall be shown on the building plans or calculation sheet.

3. Pipe Insulation. All steam and steam condensate return piping and all continuously circulating domestic or heating hot water piping which is located in attics, garages, crawl spaces, underground or unheated spaces other than between floors or in interior walls shall be insulated to provide a maximum heat loss of 50 BTU/hour per linear foot for piping up to and including 2 inch and 100 BTU/hour per linear foot for larger sizes. Piping installed at depth of 30 inches or more complies with these standards..

4. Mechanical Refrigeration Cooling Equipment Efficiency. An Energy Efficiency Ratio (EER) of 8.0 or better must be achieved by any mechanical refrigeration cooling equipment system installed in a dwelling unit to which this resolution applies. Where a coefficient of performance is used the value for the summer must be 2.34 or better. In the case of a split system, the power consumption of the interior blower is added to the power consumption of the condensing unit in calculating the system's efficiency.

IV
PATH I (PRESCRIPTIVE METHOD)

Buildings meeting all of the following criteria will fulfill the required energy conservation aspects of this code with no overall performance calculations required.

Calculations using the applicable methods outlined in Path II may be employed to demonstrate compliance of alternatives to any particular section of Path I. Thermal trade-offs between sections of Path I must be done by using Path II or by referring to approved thermal trade-offs table developed by the Building Official.

A. Walls. All exterior walls (excluding windows and doors) shall use a minimum of R-19 batt insulation between 2 x 6 studs. Group H structures must have light colored walls or shaded walls. Fifteen percent (15%) of the wall area may be dark colored to allow for trim and color accents. (Group I structures have no wall color requirement).

Exceptions:

1. All exterior walls shall achieve a composite resistance value (Rt) of 16.83 if the insulation is not penetrated by framing, and Rt of 20.00 if the insulation is penetrated by the framing or furring.

2. Heavy walls with exterior insulation not penetrated by furring or framing shall have an Rt of 11.78, and Rt of 14.00 if the insulation is penetrated by furring or framing.

3. Group H structures with dark colored walls shall increase their applicable Rt requirements by thirty percent (30%).

4. Walls may have R-11 installed between studs if paragraph D.4 is followed.

5. The equivalent of R-19 material may be used between 2" x 4" studs.

B. Roof/Ceilings; Ceiling/Attics. All roof/ceilings and ceiling/attics must use insulation achieving a minimum resistance of R-26 for the insulation itself. Occupancies having roof surfaces unshaded on August 21, at 8:00 a.m., 12:00 noon, or 4:00 p.m., shall be no darker than No. 7 on the Munsell color chart. Roofs having unshaded areas and color darker than No. 7 must increase the total insulation to yield R-48 for the insulation itself.

Exceptions:

1. All roof/ceilings and/or ceiling/attics sections shall achieve a composite resistance value (Rt) of 22.81 if the insulation is not penetrated by framing or furring and Rt of 27.37 if the insulation is penetrated by the framing or furring. (California Administrative Code, Title 25, Chapter 1, Subchapter 1, Article 5, section 1094(c)). Blown insulation (loose fill type) shall be considered to be penetrated by the framing.

2. The roof/ceiling and/or ceiling/attic sections of the dwelling unit as a whole may be insulated to values greater and/or less than required in (1) above if the resulting heat loss equals or is less than that which would occur if the values required in (1) above were met, or if the thermal resistance values of the ceiling areas satisfy the following equation:

$$\begin{aligned} 1/Rt \text{ required} = {} & (\text{Area A}/\text{Total Area})(1/Rt \text{ achieved}) \\ & + (\text{Area B}/\text{Total Area})(1/Rt/\text{achieved}) \\ & + \ldots + (\text{Area N}/\text{Total Area})(1/Rt \text{ achieved}) \end{aligned}$$

3. In occupancies with roof/ceilings or ceiling/attics located beneath roofs darker than Munsell Value 8.0 the following equation is used to determine to insulation multiplier.

$$\left(\frac{8.0 - \text{Munsell Value}}{4} \right) 1.84 = \text{Insulation Multiplier}$$

This insulation multiplier is applied to the appropriate standards in (1) above to yield the required Rt values. Example:

If the Munsell Value is 5.0 then:

$$\left(\frac{8.0 - 5.0}{4} \right) (1.84) = 1.38$$

Thus an Rt of 37.77 must be supplied instead of 27.37 in (1) above.

C. Floors. Suspended floors over a ventilated crawl space or other unheated space shall have insulation with a minimum resistance of R-11. Concrete slabs on grade require no insulation.

Exceptions:

1. Suspended floors over an unheated space shall achieve a composite resistance value (Rt) of 10.52 if the insulation is not penetrated by framing, and Rt of 12.50 if the insulation is penetrated by framing.

2. Heavy suspended floors with exterior insulation shall achieve a composite resistance value (Rt) of 7.36 for insulation not penetrated by framing members, and Rt of 8.75 for insulation penetrated by framing members.

D. Glazing Area. Exterior single-pane glazing (windows, skylights, etc.) may not exceed 12% of the floor area. Exterior double-pane glazing may not exceed 17% of the dwelling unit's floor area.

Exceptions:

1. A combination of single and double-pane glazing may be used so long as the area of the single plus the area of the double glazing divided by 1.4 is not greater than 12% of the dwelling unit's floor area.

2. A combination of single and/or double pane glazing with interior shutters may be used to increase the allowed glazing provided that:

a. The interior shutters are of a permanent construction and installed so that they are operable, and tight fitting or weather-stripped so that a seal is created.

b. The areas in each treatment do not exceed those allowed by the following procedure:

$$(FA)(.11) = Area_S + (Area_D)(.64) + (Area_{shut})/Rt$$

Where:

FA = Floor Area (square feet)
$Area_S$ = Area in single-pane glazing (square feet)
$Area_D$ = Area in double-pane glazing (square feet)
$Area_{shut}$ = Area in interior shuttered glazing (square feet)
Rt = The composite resistance of the shutter-glazing systems.

3. When the area of glazing allowed by application of (1) or (2) is exceeded, the excess area will be considered justified if all the following conditions are met:

a. Glazing must be south facing. If it is mounted other than vertically, it must be tilted at least 30 degrees up from the horizontal to face south.

b. It must be clear. (Shading coefficient numerically greater than or equal to .80 for the glazing itself).

c. It must receive full direct sun from 10:00 a.m. to 2:00 p.m. (PST) on December 21.

d. For each square foot of glazing being justified, the building must contain a heat storage capacity (HS) equivalent to 1500 BTU's/day, located inside the insulated shell of the structure, and not covered with insulation materials such as carpet yielding an Rt of 1.0 or greater. The following will allow a quick method for calculation of mass needed for each square foot of exempted glazing:

118 square feet of interior stud partition wall (2" x 4"s - 16" l.c. with 1/2" gypsum two sides).
234 square feet of exterior stud wall or ceiling (2" x 6"s - 16" o.c. with 1/2" gypsum inside, insulation, and various external treatments).
42 square feet of 8 inch lightweight concrete block masonry exterior wall insulated externally, cores filled for structural support only.
30 square feet of concrete slab bloor provided with a steel trowel finish, exposed aggregate, tile (vinyl, asbestos, or ceramic), terrazo, or hardwood parque not greater than 1/2 inch thick.
(NOTE: Lightweight stud frame walls are assumed to flux 10 degrees F: heavy walls are assumed to flux 5 degrees F. See Definitions E and K.)

4. When R-11 insulation is used in the walls the following steps must be followed:

a. In D above, the 12% becomes 10% and the 17% becomes 14%.

b. If the exceptions are to be applied then each time 11% appears 9% is substituted in its place.

E. Glazing Shading.

1. All glazing which is not oriented to the north must be shaded to protect it from direct solar radiation for the hours of 8:00 a.m., 10:00 a.m., 12:00 noon, 2:00 p.m. and 4:00 p.m. (PST), September 21. Shading shall be demonstrated to the satisfaction of the city with architectural and design approval. Drawings showing shadows cast by shading systems, or scale models suitable for use in the solar-ranger set-up by the Building Official, or the use of approved shade screen systems may be employed to demonstrate compliance.

2. Interior mounted shutters meeting the following specifications may be utilized to meet the shading requirements:

a. The exterior oriented side must be very light in color (Munsell of 9.0 or greater) and flat.

b. The shutters must be tight fitting or all cracks or edges in the system must be weatherstripped to create a seal.

c. The shutters must be opaque.

d. A composite resistance value of Rt = 1.0 for the shutters must be achieved.

3. Exterior mounted shading systems meeting the following specifications may be utilized to meet the shading requirements.

a. They shall be of permanent materials and construction. A permanent frame with sheathing having a life expectancy of five years minimum must be provided and guaranteed by the builder.

b. For the required design hour, the shading device must be capable of intercepting 100% of the direct beam solar radiation, or provide a minimum shading coefficient of 0.2 or less. If the shading system at a design hour does not perform to these standards, then the portion of the glazing which is left exposed is to be calculated and added to the accumulated unshaded glazing total.

4. Other types of shading systems are allowed if they comply with either of the following:

a. All on-site and off-site obstructions to the sun, providing 80% attenuation of the direct solar beam, may be considered as external shading devices and may be accounted for in the summer shading calculations.

b. A shading system may be temporary, provided that it is designed and constructed to function to the standards above and built to last until its function is replaced by plantings. Plan and elevation drawings must show expected plant configuration and accurately state the number of years required for the projected plant growth. Final occupancy permits shall not be issued until the specified plants are in place.

F. Ventilation for Summer Night Time Cooling.

1. Where design of the dwelling unit is such that openable windows may only be provided along one elevation, mechanical cross ventilation must be installed to provide 15 air changes per hour ducted to the exterior.

2. Where mechanical ventilation is provided to give 30 air changes per hour ducted to the exterior and actuated by a timer or thermostat, set to give evening and nightime operation when the outside temperature is 80 degrees F or cooler then the inside temperature, the mass credit is doubled due to the increased effectiveness of the mass.

V
PATT II (PERFORMANCE METHOD)

Buildings regulated by the Residential Energy Conservation Code that do not meet the criteria of Path I must be calculated to show that the proposed building will not exceed the standards set forth in Section 3 or Ordinance No. 718. The required calculation schedule is outlined below. (NOTE: More precise calculations may be submitted using ASHRAE or other comprehensive methods provided that the same design days are used).

Commonwall U.B.C. Group I dwelling units may increase the permissible thermal standards for the Heat Loss or Heat Gain using the following equation:

$$TS = TS_H + TS_1 - TS_H) (1 = SCA/(1.5)(FA))$$

Where:

- TS = The Thermal Standard which is applicable to the dwelling unit (BTU's/(sq.ft.)(day)).
- TS_H = The Thermal Standard for Group H structures (BTU's/(sq.ft.)(day))
- TS_1 = The Thermal Standard for a detached Group I dwelling unit of the same floor area (BTU's/(sq.ft.)(day))
- SAC = The Surface Area in Common with other dwelling units such as ceilings, walls, and floor (square feet)
- FA = The dwelling unit's Floor Area (square feet)

A. <u>Winter Calculations.</u>

1. The Total Day's Heat Loss shall not exceed the standards set in the Residential Energy Conservation Ordinance, Section 3.

2. Winter heat loss calculations shall be based on the following formula:

$$TDHL = (DHL - SHGC)/(FA)$$

Where:

- TDHL = Total Day's Heat Loss (BTU's/(sq.ft.)(day))
- DHL = Day's Heat Loss (BTU's/day)
- SHGC = Solar Heat Gain Credit (BTU's/Day)
- FA = Floor Area of dwelling unit (sq.ft.)

3. The Design Day for sun angle considerations is December 21 at latitude 32" north or 33 degrees 43' N. The outside daily temperature average for late December early January 54 degrees F, yielding a 18 degrees F difference between the inside (72 degrees F) and the outside (54 degrees F) average daily temperatures. The number of degree hours in the design day is the temperature difference times 24 hours or 432 for Indio. This figure is used as described in paragraph (4)(a) below. (NOTE: This design, outdoor condition, is not intended to be for equipment sizing, but rather is meant to serve the purpose of performance design for energy conservation by more closely predicting the long term average conditions and energy use of the structure. Equipment sizing will require additional standard peak load calculations.)

4. Calculation of Day's Heat Loss (DHL): Winter heat loss is determined by the composite resistance (Rt) of the exterior building surface to heat transfer to the outside air from the heated interior spaces.

$$DHL = HL + SHL$$

where:

- DHL = Day's Heat Loss (BTU's/day)
- HL = Heat Loss from outside surface elements (except slab) (BTU's/day)
- SHL = Slab on grade Heat Loss (BTU's/day)

a. The heat loss for all surfaces (except slabs on grade) facing the outside air or unheated spaces may be determined by the following formula:

$$HL = (A_1/RT_1)(432) + (A_2Rt_2)(432) + \ldots + (A_n/Rt_n)(432)$$

where:

- HL = Heat Loss from exterior surface element except a slab on grade (BTU's/day).
- A = Area of the opaque exterior surface element (sq.ft.)
- Rt = The element's composite thermal resistance ((hours)(Deg.F)(sq.ft.)/BTU)
- 432 = Indio Design Day Degree Hours ((Deg. F)(hours)/Day)

All exterior elements (walls, ceilings, doors and suspended floors) which are exposed to unheated enclosed or partially enclosed spaces shall be calculated as if they are exposed to outside conditions, or the temperature difference may be altered according to accepted ASHRAE procedures for surfaces adjacent to unheated spaces.

b. Concrete slab floors on grade lose heat in direct relation to the perimeter dimension in linear feet. The following formula applies:

$$SHL = (F)(P)(432)$$

where:

SHL = Heat Loss from Slab (BTU's/Day)
F = The Thermal conductivity of the edge of the slab with F = 0.81 (BTU/(foot)(hour)(Deg. F)) where no insulation is used and F = 0.55 where slab is insulated with edge insulation of R = 4.5 minimum. The insulation shall come within one inch of the top of the slab and extend sixteen inches below grade.
P = Perimeter dimension (feet)
432 = Indio Design Day Degree Hours ((Deg. F)(hours)(day))

c. Conducted window heat loss is one of the two ways windows transfer heat. The following formula applies:

$$WHL = (432)(A_1/R_1 + A_2/R_2 + A_S/R_S + A_{SL}/R_{SL})$$

where:

WHL = Conducted Window Heat Loss (BTU's/day)
A_1 = Area in single pane glazing (sq.ft.)
R_1 = Resistance of single pane glazing ((hours)(degrees F)(sq.ft.)/BTU))
A_2 = Area in double pane glazing (sq.ft.)
R_2 = Resistance of the double pane glazing ((hours)(degrees F)(sq.ft.)/BTU)
A_S = Area of shuttered glazing (sq.ft.)
R_S = Resistance of the shutter glazing system ((hours)(degrees F)(sq.ft.)/BTU)
A_{SL} = Area of skylights (sq.ft.)
R_{SL} = Resistance of the skylights (if a combination of single, double and shuttered is used then this form expands on to 2 or 3 as appropriate).((Hours)(Degrees F)(sq.ft.)/BTU)
432 = Indio Design Day Degree Hours ((hours)(degrees F)/day)

5. Calculation of Solar Heat Gain Credit (SHGC). Direct use of solar energy is dependent on the Day's Solar Heat Gain (DSHG) through the glazing, the Heat Storage (HS) characteristics of the building, and the Solar Climatic Variable (SC). The following steps are to be followed to calculate the SHGC:

a. Calculate the Day's Solar Heat Gain (DSHG), by adding up the Solar Heat Gain for each daylight hour or December 21 design day for each square foot of glazing receiving sun.

$$DSHG = (HSHG_1 + HSHG_2 + \ldots + HSHG_n)(SCV)$$

where:

DSHG = Day's Solar Heat Gain (BTU's/day)
HSHG = Hour's Solar Heat Gain. HSHG is found according to the procedure described in Definition I. The number of hours added depends on the hours of sunlight on the glazing surface in question.
SCV = Solar Climatic Variable (no units). SCV = 0.86 for Indio. This was determined by averaging the mean fraction of possible sunshine available for each month of the winter heating season (December, January, February).

b. Calculate the Heat Storage Capacity of the building (HS). (See Definition K for calculation procedure).

c. Then the Solar Heat Gain Credit (SHGC)(BTU's/Day) equals: SHGC - DSHG or HS, whichever is less.

B. Summer Calculations.

1. The Total Day's Heat Gain (TDHG) shall not exceed the standard set in the Residential Energy Conservation Ordinance, Section 3.

2. Summer heat gain calculations shall be based on the following formula:

$$TCHG = (CWHG + DRHG + OHG - HS)/FA$$

where:
TDHG = Total Day's Heat Gain (BTU's/(sq.ft.)(day))
CWHG = Conducted window heat gain (BTU's/day)
DRHG = Day's Radiant Heat Gain (BTU's/day)
OHG = Opaque Heat Gain (BTU's/day)
HS = Heat Storage (BTU's/day)
FA = Floor area (sq.ft.)

3. Conducted Window Heat Gain. The structure's glazing is divided into groups on the basis of orientation and treatment. Calculations establishing the heat gain conducted through each glazing group are based on the following formula:

$$CWHG = (STD\ (\frac{A_i}{R_i} + \frac{A_{ii}}{R_{ii}} + \ldots + \frac{A_n}{R_n})$$

where:
CWHG = Conducted Window Heat (BTU's/day)
STD = Summed hourly temperature differences (degrees F/day)
A_i = Area of glazing group (square feet)
R_i = Thermal Resistance of group ((hours)(degree F)(square feet)/BTU)

4. Day's Radiant Heat Gain is calculated for each of the design day's design hours (5 total).

$$\begin{aligned} DRHG = 2\ & (SHFG_{800})(GAUS_{800} + (SC_{800})(GAS_{800})) + \\ & (SHGF_{1000})(GAUS_{1000} + (SC_{1000})(GAS_{1000})) + \\ & (SHGF_{1200})(GAUS_{1200} + (SC_{1200})(GAS_{1200})) + \\ & (SHGF_{1400})(GAUS_{1400} + (SC_{1400})(GAS_{1400})) + \\ & (SHGF_{1600})(GAUS_{1600} + (SC_{1600})(GAS_{1600})) \end{aligned}$$

The DRHG's are then summed to yield the total DRHG:

$$DRHG = DRHG_1 + DRHG_2 + \ldots + DRHG_n$$

where:
DRHG = Day's Reduced Heat Gain (BTU's/day)
$DRHG_i$ = Day's Radiant Heat Gain for one glazing group
$SHGF_{iiii}$ = Solar Heat Gain Factor at time iiii being calculated (BTU's/(hours)(sq.ft. of glazing))
SC_{iiii} = Shading Coefficient (see Definition H) (unit less)
$GAUS_{iiii}$ = Glazing area unshaded at time iiii (sq.ft.)
GAS_{iiii} = Glasing area shaded at time iiii (sq.ft.)

5. Opaque Heat Gain is calculated by the following formula:

$$\begin{aligned} OHG\ = & (STETD_1)(A_1)(\frac{1}{R_1}) + (STETD_2)(A_2)(\frac{1}{R_2}) + \ldots + \\ & (STETD_n)(A_n)(1/R_n) \end{aligned}$$

where:
OHG = Opaque Heat Gain (BTU's/Day)

STETD = Summed Total Equivalent Temperature Difference for the Building element (degrees F/Day)
A = Area of building element (sq.ft.)
R = Thermal Resistance of the building element ((hours)(degrees F)(sq.ft.)/BTU)).

6. Heat Storage Capacity (HS). Where the building design provides for ventilation in minimum conformance with Section 4. F, credit can be taken for the Heat Storage capacity of the structure. (NOTE: When calculating the heat storage capacity for the summer, no credit may be taken for exterior elements).

PASSED, APPROVED and ADOPTED this 6th day of July, 1977, by the following vote, to wit:

AYES: Councilmen Harlow, Zokosky, Mayor Rinderhagen

NOES: Councilman Reed

ABSENT: None

ABSTAINING: Councilman Hernandez

Raymond M. Rinderhagen
RAYMOND M. RINDERHAGEN, Mayor
City of Indio, California

ATTEST:

Saundra L. Juhola
SAUNDRA L. JUHOLA, City Clerk
City of Indio, California

STATE OF CALIFORNIA)
COUNTY OF RIVERSIDE) ss.
CITY OF INDIO)

I, SAUNDRA L. JUHOLA, City Clerk of the City of Indio, do hereby certify the foregoing to be a full, true and correct copy of Resolution No. 2940 of the City Council of the City of Indio, adopted by said City Council at a regular meeting on the 6th day of July, 1977.

Saundra L. Juhola
SAUNDRA L. JUHOLA, City Clerk
City of Indio, California

ORDINANCE NO. 718

AN ORDINANCE OF THE CITY COUNCIL OF THE CITY OF INDIO, CALIFORNIA, ESTABLISHING ENERGY CONSERVATION PERFORMANCE STANDARDS FOR RESIDENTIAL CONSTRUCTION WITHIN THE CITY OF INDIO.

The City Council of the City of Indio, California, does hereby ordain as follows:

I
FINDINGS

A. The people of the State of California face the likelihood of a major energy shortfall and the certainty of rapidly rising energy costs due to uncertainties about present and future supplies of natural gas, and the inability of powerplant construction to keep pace with the rising demand for electricity. Energy demand for the heating and cooling of residential structures has been rising faster than demand in other sectors and rising household energy bills are becoming an increasing economic burden for lower and middle income families.

B. The State of California has adopted an energy insulation standard under the provisions of the California Administrative Code, Title 25, Chapter 1, Subchapter 1, Article 5. This standard will make an important contribution to improving housing in the State, but due to the unique characteristics of the Indio climate, the State regulations are deemed to be inadequate for use in the City of Indio.

C. The hot-dry, low desert climate of Coachella Valley has been extensively studied. Research has identified many ways in which climatically adopted structures can be built in Coachella Valley using existing methods of construction. Properly designed homes will provide human comfort without the extensive mechanical cooling which is presently required.

D. Many years of research[1] in the same type of climate and similar climates have established the following facts which are applicable to Coachella Valley.

1. An experimental room with large windows facing west regularly achieved temperatures in excess of 140 degrees F during the summer in Davis.[2] The problem of unshaded windows is inadequately dealt with in the State code. Consequently, dwellings which will overheat to such an extent that they are unfit for human habitation may be built under the State standard. Conditions in Coachella Valley would result in temperatures of up to 170 degrees F.

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1 *See Research Bibliography.*

2 *R. D. Cramer and L. W. Neubauer, "Solar Radiant Gians Through Directional Glass Exposure," American Society of Heating, Refrigeration and Air Conditioning Engineers, 1958; ASHRAE Transactions (1959), Vol. 65, No. 59, p. 499.*

2. It has been found in experimental structures in Davis that solar heat gains from properly oriented windows can significantly reduce the need for heating in the winter.[3] This factor is not credited in the State code. Coachella Valley has 50% more sunshine than Davis with one third the heating degree days. Properly oriented windows will further reduce and most cases may eliminate the need for supplemental heating because of these very favorable conditions.

3. It has been found that the thermal capacity or heat storage ability of the building itself can help to ameliorate daily temperature extremes of both summer and winter.[4] This factor is not accounted for in the State code. The use of adobe blocks in structures throughout the arid southwest attests for the value of buildings with heat storage capacity in Coachella Valley.

4. In Phoenix, Arizona, between August 1967 and July 1968 an experiment with a prototypical house was run demonstrating the feasibility of "Natural" air conditioning and heating. Comfortable temperatures were maintained in the structure throughout the year without mechanical heating and cooling.[6]

5. A low-cost version of a natural cooling system combined with a shady structure developed for the desert was set up and tested at the Indio Date and Citrus Station on July 1976. The potential cooling power of the "cool pool" was demonstrated by the fact that the highest temperature reached was 20 to 30 degrees F below the day's maximum temperature running at a very consistent 80 degrees F.

E. In July 1975, the City of Indio received a HUD grant for an energy conservation project. A field research program was undertaken in Indio designed to study the performance of actual buildings. Both the thermal performance and actual energy use were examined. It was found that:

1. Wintertime field research found that those units which had the benefits of some south facing windows were warmer than those units without.

2. Natural gas use data was gathered from the local utility company and shows that even though the winters are mild and the skies clear, one-fifth of the annual primary energy use is for winter heating, or 57% of the annual natural gas use.

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3 L. W. Neubauer, "Shapes and Orientations of Houses for Natural Cooling," Transactions of the American Society of Agricultural Engineers, Vol. 15, No. 1, pp. 126, 127, 128 (1972).

4 R. D. Cramer and Loren W. Neubauer, "Thermal Effects of Floor Construction," ASHRAE Journal (January 1961), six pages. Victor Olgyay, Design with Climate, Princeton University Press, Princeton, New Jersey, 1963, pp. 110-118. B. Givoni, Man, Climate and Architecture, Elsevier Publishing Co., Ltd., New York, pp. 113-137, pp. 313-320.

5 James Marston Fitch and Daniel P. Branch, "Primitive Architecture and Climate Scientific American, December, 1960, pp. 134-144.

6 H. R. Hay and J. L. Yellot, ASHRAE Transactions 1969 Part 1, Vol. 75, pp. 165-177. J. L. Yellot and H. R. Hay, ASHRAE Transactions 1969 Part 1, Vol. 76, pp. 178-190.

3. Summertime field research found that many dwelling units are at least partly shaded but that many units suffer from improper orientation, inadequate shading, and inadequate insulation.

4. Electricity use data gathered from the local utility company show that 41% of the annual primary energy use of a dwelling unit goes to provide comfort or 60% of the annual household electricity use is for cooling.

F. As part of the above-mentioned study, the Indio climate was examined in light of the needs for energy conservation and the following findings were made:

1. The average year's daily temperature is 73.1 degrees F indicating the theoretical possibility of maintaining human comfort throughout the year.

2. Soil temperatures taken at a site in a climate like Coachella Valley's varied from 88 degrees F to 53 degrees F at a 5 foot depth, 76 degrees F to 56 degrees F at a 10 foot depth, and 73 degrees F to 59 degrees F at a 15 foot depth.[7] These soil temperatures make the building of a dwelling unit into the ground or with berms a sensible approach.

3. The Indio climate has four definable seasons:

a. A short cool winter in the months of December, January, and February, with hard freeze snaps possible. The sunshine is abundant in even the coldest month of January with more than 80% of the possible sunshine available. The average temperature is 56 degrees F with average highs of 72 degrees F and average lows of 40 degrees F. The recorded extremes are from 13 degrees F to 96 degrees F.

b. A comfortably mild transition season in the months of November, March and April preceeds and follows the winter season. The average high temperature is 83 degrees F and the average low temperature is 56 degrees F. The recorded extremes are 23 degrees F and 103 degrees F.

c. A warm days with cool nights season in May and October is the third identifiable season. The average high temperature is 93 degrees F and the average low temperature is 62 degrees F. The recorded extremes are 37 degrees F and 113 degrees F. This combination of maximum and minimum temperatures insures the possibility of passive cooling by nightime ventilation.

d. A hot-dry days with warm nights season on the months of June, July, August, and September is the fourth season. This season includes intensely hot weather events requiring strategies similar to those used in climates with cold weather. Average high temperatures are 104 degrees F and the average low temperatures are 74 degrees F. The nights are often too warm to provide complete cooling

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7 *McClatchie, A. J. (1904), "Relation of Weather to Crops," Arizona Agricultural Experiment Station Bulletin, p. 375.*

by ventilation. However, for 54% of the time between 2:00 a.m. and 9:00 a.m. in the morning active ventilation could eliminate the need for cooling. In addition, natural cooling using radiative and evaporative cooling has been proven to work very effectively. (See D 4 & 5 above).

4. The existence of sunny-cool winters with only 870 degree heating days in intensity allows for greatly reduced heating energy needs if the following conditions are met:

a. The walls, floors and ceilings are adequately insulated;

b. Adequate south-facing glass exposed to the winter sun is provided; and

c. Adequate thermal storage capacity is provided within the insulated shell of the structure.

5. In summer there are 1458 full load cooling hours and 2724 hours with the outside temperature above 80 degrees F. But, for a total of 54% of the early morning hours (2:00 a.m. to 9:00 a.m.) the outside air temperature is below 80 degrees F. Natural cooling is cost effective and feasible if the following conditions are met:

a. The windows are protected from direct solar radiation and shuttered if more than five percent of floor area is in windows;

b. The walls, floors and ceilings are heavily insulated;

c. Adequate thermal storage capacity is provided within the structure;

d. Cross-ventilation with fans for nightime cooling of the living space is provided; and

e. All exposed surfaces are very light in color.

G. Due to the above stated factors, it has been found that:

1. Considerably better minimum performance levels can be required in Indio than are provided for by the State code without unduly restricting designs and raising costs, or requiring new technologies.

2. The present State code allows the construction buildings that will be unfit for human habitation in the event of the interruption in gas or electrical service during one of the frequently occurring cold or hot weather events. Therefore, the present State code, by its failure to adequately address the heat loss and heat gain considerations of glazing and glazing orientation, does not adequately deal with the Indio climatic conditions.

8 Degree Day - A unit, based upon temperature difference and time. For any one day the day's average temperature is calculated. Each degree fahrenheit that the average is below 65 degrees F is one degree day. Thus a 50 degree F average temperature day is a 15 degree day and a season with the equivalent of 100 such days would be a 1500 degree heating day season.

3. Considerable reduction in the real cost of housing can be achieved in buildings with good thermal performance, that reduces utility bills. In addition, the initial costs of improving the structure's thermal performance is usually offset by the resultant savings due to the smaller capacity heating and/or cooling equipment required for a thermally efficient structure.

4. The continued attractiveness of Indio and the surrounding areas will be enhanced by the encouragement of structures which will provide higher levels of human comfort with comparatively low energy inputs for space heating and cooling.

II
DEFINITIONS

The following words and phrases shall have the meanings respectively ascribed to them by this section:

A. Winter Design Day shall refer to a day upon which it shall be assumed, for purposes of structural heat loss calculations, that all of the following climatological conditions exist:

1. The sun's path and resultant angles of direct sunlight shall be those which occur on December 21 of each year at latitude 34 degrees north. These angles can be approximated by using latitude 32 degrees north data. (See Table 1)

2. The sun's intensity through glazing shall be calculated for December 21 of each year at latitude 33 degrees 43' north; this can be approximated by using latitude 32 degrees north data. (See Table 1)

3. The 24-hour average outside temperature is 54 degrees F.

4. For the sake of determining the external air film coefficient, the wind speed shall be assumed to be 15.0 mph in accordance with ASHRAE procedures.

B. Summer Design Day, as used in this ordinance, shall refer to a day upon which it shall be assumed, for purposes of structural heat gain calculations, that all of the following climatological conditions exist:

1. The sun's path and resultant angles of direct sunlight shall be those which occur on September 21 of each year at latitude 33 degrees 43' north. These angles can be approximated by using latitude 32 degrees north. (See Table 1)

2. The sun's intensity through glazing shall be calculated for September 21 of each year at latitude 33 degrees 43' north. This can be approximated by using latitude 32 degrees north data. (See Table 1)

3. The outside temperatures on September 21 shall be assumed to be, at each hour, Pacific Standard Time, as follows:

Time A.M.	Temp. Degrees F	Time P.M.	Temp. Degrees F
1:00	86	1:00	110
2:00	84	2:00	112
3:00	82	3:00	114
4:00	81	4:00	114
5:00	80	5:00	112
6:00	78	6:00	109
7:00	80	7:00	105
8:00	86	8:00	101
9:00	93	9:00	97
10:00	99	10:00	93
11:00	102	11:00	90
12:00	106	12:00	88

4. For the sake of determining the exterior air film coefficient, the wind speed shall be 15 mph in accordance with ASHRAE procedures.

C. Floor Area shall refer to the total habitable area of a dwelling unit (expressed in square feet) which is within the exterior face of the insulated shell of the structure and which is heated or cooled.

III
MINIMUM PERFORMANCE STANDARDS ADOPTED

The City of Indio hereby adopts minimum standards for the thermal performance of buildings to be constructed within the City of Indio. In order to achieve maximum thermal performance, the performance standards have been carefully adjusted to the special problems and opportunities of the Indio climate. These standards shall apply to all residential structures designated Group H and Group I in the Uniform Building Code.

A. Winter Performance Standard. For a winter performance standard the Total Days Heat Loss per square foot of floor area during the winter design day shall be as follows: for single-family, detached structures designated U.B.C. Group I, see Table 2; for multiple dwellings, U.B.C. Group H, the Total Days Heat Loss shall not exceed 108 BTU's per square foot of floor area. Commonwall Group I structures shall meet Group H standards. The resolution establishing methods of compliance with the performance standards will allow for numerically increase the permissable standard on the basis of surface areas in common in order to equitably deal with the variability which occurs in this class of dwelling units.

B. Summer Performance Standard. For a summer performance standard, the Total Days Heat Gain per square foot of floor area during the Summer Design Day shall be as follows: for single family, detached structures, U.B.C. Group I, see Table 2; for multiple dwellings U.B.C. Group H, the Total Days Heat Gain shall not exceed 86 BTU's per square foot of floor area. Commonwall Group I structures shall meet Group H standards. The resolution establishing methods of compliance with the performance standards will allow for numerically increasing the permissible standard on the basis of surface areas in common in order to equitably deal with the variability which occurs in this class of dwelling units.

IV
METHODS OF COMPLIANCE WITH PERFORMANCE STANDARDS TO BE ESTABLISHED BY RESOLUTION

Standard methods for calculating the performance of a proposed structure to determine compliance with the standards of this ordinance shall be adopted by resolution of the City Council.

V
ADMINISTRATION AND ENFORCEMENT

A. The provisions of this ordinance and the resolution establishing the methods of compliance shall be administered by the Building Official of the City of Indio.

B. No building permit shall be issued by the Building Official for any new structure subject to this ordinance unless such structure is found to be in compliance with the winter and summer performance standards hereby established.

Table 1

Solar Position and Intensity; Solar Heat Gain Factors for Deg North Latitude*

Date	Solar Time A.M.	Solar Position Alt.	Azimuth	Direct Normal Irradiation Btuh/sq.ft.	Solar Heat Gain Factors, Btuh/sq.ft. N	NE	E	SE	S	SW	W	NW	Hor.	Solar Time P.M.
Sept. 21	7	12.7	81.3	163	10	95	159	128	19	9	9	9	30	5
	8	25.1	73.0	240	18	103	215	139	60	18	13	13	[illegible]	4
	9	36.8	62.1	272	24	64	202	213	155	24	24	24	158	3
	10	47.3	47.5	287	29	32	154	203	141	30	29	29	[illegible]	2
	11	55.0	26.8	294	31	32	61	174	164	59	31	31	[illegible]	1
	12	59.0	0.0	296	32	32	34	120	171	120	34	32	[illegible]	12
			Half Day Totals		[illegible]	355	645	[illegible]	575	194	[illegible]	[illegible]	[illegible]	
Dec. 21	8	10.3	53.8	176	7	18	135	167	[illegible]	7	7	7	[illegible]	4
	9	19.8	43.6	257	13	14	162	[illegible]	171	15	13	13	72	3
	10	27.6	31.2	287	18	18	127	246	217	52	18	18	119	2
	11	32.7	16.4	300	20	20	63	222	240	116	20	20	143	1
	12	34.6	0.0	304	21	21	23	177	252	177	23	21	153	12
			Half Day Totals		67	76	432	947	644	273	[illegible]	67	[illegible]	
					N	NW	W	SW	S	SE	E	NE	Hor.	P.M.

Total Solar heat gains for DS (1/2 in.) sheet glass. Based on a ground reflectance of 0.20 and values in Tables 1 and 9.

* From *Handbook of Fundamentals*, 1972, American Society of Heating, Refrigeration and Air Conditioning Engineers.

Table 2[9]

DETACHED GROUP I DWELLING UNIT THERMAL STANDARDS

Floor Area (sq. ft.)	Winter Heat Loss (BTUs/(sq.ft.)(day))	Summer Heat Gain (BTUs/(sq.ft.)(day))
500	204	175
1000	179	152
1500	162	143
2000	144	138
2500	138	135
3000	134	130

NOTE: Direct interpolation shall be used for floor areas not shown.

VI
CONFLICTING ORDINANCES REPEALED

All ordinances or portions of ordinances which conflict with the provisions of this ordinance area, to the extent of such conflict, hereby repealed.

9 Infiltration and internal heat production are not considered under the requirements of these standards. These are very important considerations in the real performance of a building and must be estimated when sizing heating and cooling devices whether conventional or solar.

VII

EFFECTIVE DATE

This ordinance shall become effective on and after the nintieth (90) day following its adoption.

PASSED, APPROVED and ADOPTED this 6th day of April, 1977, by the following vote, to wit:

AYES: Councilmen Harlow, Hernandez, Reed, Mayor Rinderhagen

NOES: None

ABSENT: Councilwoman Zokosky

Raymond M. Rinderhagen

RAYMOND M. RINDERHAGEN, Mayor
City of Indio, California

ATTEST:

Saundra L. Juhola

SAUNDRA L. JUHOLA, City Clerk
City of Indio, California

STATE OF CALIFORNIA)
COUNTY OF RIVERSIDE) ss.
CITY OF INDIO)

I, SAUNDRA L. JUHOLA, City Clerk of the City of Indio, California, do hereby certify that the foregoing Ordinance No. 718 was introduced at a regular meeting of the City Council of said City duly held on the 16th day of March, 1977, and was passed on and adopted by said City Council at a regular meeting thereof, duly held on the 6th day of April, 1977, not being less than five (5) days after the date of introduction thereof.

IN WITNESS WHEREOF, I have hereunto placed my hand and affixed the official seal of the City of Indio, California, this 6th day of April, 1977.

Saundra L. Juhola

SAUNDRA L. JUHOLA, City Clerk
City of Indio, California

Date	Solar Time A.M.	Solar Position		Direct Normal Irradiation Btuh/sq.ft.	Solar Heat Gain Factors, Btuh/sq.ft.									Solar Time P.M.
		Alt.	Azimuth		N	NE	E	SE	S	SW	W	NW	Hor.	
Sept. 21	7	12.7	81.9	163	10	95	159	128	19	9	9	9	30	5
	8	25.1	73.0	240	18	103	215	199	60	18	18	18	96	4
	9	36.8	62.1	272	24	64	202	218	105	24	24	24	158	3
	10	47.3	47.5	287	29	32	154	208	141	30	29	29	204	2
	11	55.0	26.8	294	31	32	81	174	164	59	31	31	234	1
	12	58.0	0.0	296	32	32	34	120	171	120	34	32	244	12
			Half Day Totals		128	355	846	1004	575	194	128	127	844	
Dec. 21	8	10.3	53.8	176	7	18	135	166	96	7	7	7	22	4
	9	19.8	43.6	257	13	14	162	238	171	15	13	13	72	3
	10	27.6	31.2	287	18	18	127	246	217	52	18	18	119	2
	11	32.7	16.4	300	20	20	63	222	243	116	20	20	148	1
	12	34.6	0.0	304	21	21	23	177	252	177	23	21	158	12
			Half Day Totals		67	76	482	947	844	273	68	67	440	
					N	NW	W	SW	S	SE	E	NE	Hor.	P.M.

Total Solar heat gains for DS (1/2 in.) sheet glass. Based on a ground reflectance of 0.20 and values in Tables 1 and 9.

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* *From Handbook of Fundamentals, 1972, American Society of Heating, Refrigeration and Air Conditioning Engineers.*

LIGHTING

IX. LIGHTING FOR ENERGY CONSERVATION IN INDIO

IX.1 SUMMARY. Changing lighting standards and design can provide more comfortable working conditions and save considerable energy and money. The use of natural lighting is particularly important because it can reduce heat gain due to lighting - an important factor in the Coachella Valley where air conditioning may be required six or more months every year. Existing light levels reflect the practices developed when energy was inexpensive. As energy prices continue to climb, old lighting standards were reviewed by the U. S. Government Services Administration resulting in new standards which are

The Indio City Hall demonstrates the savings possible in traditional buildings through more appropriate lighting. Light levels could be reduced as much as 1/2 to 1/4 of current levels. This would save as much as $100 - 200 month on the City utility bills. At the same time the City staff would have a more pleasant and comfortable working environment.

Equal or greater savings could be realized in most other commercial buildings in the Coachella Valley. If widespread changes are made, significant savings will save energy and money and the peak demand for electricity will be reduced.

IX.2 INTRODUCTION. In 1972, more than 20% of the electricity generated in the United States was used for lighting. If this energy had been wisely spent to provide more comfortable and safer working conditions it would not be unreasonable. Much of this energy is spent for excessive lighting that in many cases causes real discomfort. In addition, excessive lighting leads to even greater use of energy for air conditioning to offset the heat added by the lights. Proper lighting design in Indio could save considerable energy and money while providing more comfortable conditions for Indio's citizens. The support and research conducted by the City staff made this report possible.

IX.3 SEEING AND LIGHTING. The basic goal of lighting is the provision of a comfortable and pleasant visual environment for man to work in. This is not as simple as one might expect. The human eye and brain are very complex and very adaptable, making good lighting design difficult unless a few simple principals are addressed .

There are several concepts that must be understood in the discussion of lighting. The first is illumination, or the amount of light spread over a surface. This is described in the English notation by the term foot candle or in the metric system as a lux or lumen/sq m. (1 fc = 1 lm/sq.ft.=10.8lux).

Brightness is a factor of the level of illumination and the reflectance of the surface we are viewing. A white surface may have a reflectance of nearly 100% while a dark black surface may reflect only 2%. Brightness is the product of illumination multiplied by the reflectance and is also knows as "luminance." The common measurement is the foot-lambert.

Another level of complexity is added to the issue because perceived brightness may vary considerably from the physically measured brightness. For example, a car headlight is apparently very bright at night yet very dim during the day even though the measured brightness is the same. Color may have a similar effect, i.e. a white card on a light grey surface will appear much lighter than a white card on a dark blue surface.

Thus, in discussing brightness we must discuss it subjectively - for what we see. The human eye can see from around .0001 to 10,000 foot candles. It is very adaptable and can be comfortable over a very broad range of lighting intensities. Research has repeatedly shown that low light levels will not cause eye damage. Variety is essential for visual comfort and must include movement, intensity and color. The environment in which we evolved provided this stimuli and we require it for the best performance.

IX.4 LIGHTING STANDARDS AND RESEARCH. Lighting standards have risen drastically in the United States largely in spite of the research that has been done on human comfort. The history of the N.Y. School lighting standards is indicative of the changes that have occurred. Before 1910 the standard was 3 fc, between 1910-1930 it was 18 fc, between 1930-1950 it jumped to 30fc, and it has risen since then to 150 fc. In Europe, the goal of lighting engineers has been "lighting which would permit efficient work in a pleasant environment." A comparison of the standards in different countries is very instructive. There seems little question that the minimum levels recommended by the I.E.S. are entirely unjustified.

Recommended Lighting Levels In Foot-candles By Task.	*U. S. A.*[1]	*Great Britain*[2]	*France*[3]	*Germany*[4]	*Sweden*[5]	*Finland*[6]	*Belgium*[7]	*Switzerland*[8]	*Australia*[9]
Most Difficult Seeing Tasks Finest precision work. Involving: finest detail; poor contrasts; long periods of time. Such as: extra-fine assembly; precision grading; extra-fine finishing.	926–1852	139–278	139–278	370	93–185	93–185		over 93	over 185
Very Difficult Seeing Tasks Precision work. Involving: fine detail; fair contrasts; long periods of time. Such as: fine assembly; high-speed work; fine finishing.	463 926	65–139	65–139	55–93	27–46	46	46–93	27–93	65–139
Difficult and Critical Seeing Tasks Prolonged work. Involving: fine detail; moderate contrasts; long periods of time. Such as: ordinary benchwork and assembly; machine shop work: finishing of medium-to-fine parts; office work.	463 92	28 65	28 65	23 46	28	28	23 46	14 28	28 65
Ordinary Seeing Tasks Involving: moderately fine detail; normal contrasts; intermittent periods of time. Such as: automatic machine operation; rough grading; garage work areas; switchboards; continuous processes; conference and life rooms; packing and shipping.	46–93	14–28	14–28	11–23	14	14	9–23		14–28
Casual Seeing Tasks Such as: stairways; reception rooms; washrooms, and other service areas; inactive storage.	18–28	7–14	7–14	6	4–8	8	5–8	4–8	7–14
Rough Seeing Tasks Such as: hallways; corridors-passageways; inactive storage.	9–18	3–6	3–6	3	2	4	2–3		5–7

1) I. E. S. Handbook 1959, Tables 9-53, pp. 9-76 to 84. 2) I. E. S. Code 1961, Interior Lighting, p. 41; 3) L'Ass Française des Eclairagistes. Recomm. 1961, p. 33. 4) Deutsche Industrie Normen, Blatt 5053, Table I, 1953, 5) Svenska Belysningssällskapet, Lux table 1949; 6) Proceedings, C. I. E. Stockholm 1951, report 62b, p. 31; 7) Com. Nat. Belge de l'Eclairage, Code preliminaire 1951, p. 12, 8) Schw. Elektr Verein, Leitsätze 1947, S. 6; 9) Australian Standard Code No. CA. 30-1957.

1 footcandle = 1 lm/sq. ft = 10.8 lux

The fact that the standards recommended in the U.S. vary so widely from the rest, and that they have risen most markedly puts them in doubt.

A revised standard prepared by the FEA is included below. Note that it has now become a maximum level yet it is still higher than necessary for most purposes.

Table 1: Recommended maximum lighting levels

Task or area	Footcandle levels	How measured
Hallways or corridors	10 ± 5	Measured average, minimum 1 footcandle.
Work and circulation areas surrounding work stations	30 ± 5	Measured average.
Normal office work, such as reading and writing (on task only), store shelves, and general display areas	50 ± 10	Measured at work station.
Prolonged office work which is somewhat difficult visually (on task only)	75 ± 15	Measured at work station.
Prolonged office work which is visually difficult and critical in nature (on task only)	100 ± 20	Measured at work station.
Industrial tasks	ANSI-A11.1-1973	As maximum.

We have prepared a basic standard based on a review of the literature. This is included below:

Hallways or corridors	3 fc
Work and circulation areas surrounding work stations	10 fc
Normal office work	30 fc
Prolonged office work of detailed nature	50 fc

It is important to maintain a ratio close to 10:3:1 for work/foreground/background. Overly high background lighting can reduce efficiency and comfort.

Light levels can be measured using a foot candle meter ($160.00) or more approximately with a lightmeter set at ASA-100, EV = 5 at 10 fc, EV = 7, at 30 fc, EV = 9, at 50 fc, EV = 10.5-11 = 70 fc and EV = 12 at 200 fc. The light-meter is only approximate because it is set to measure the spectrum that film responds to - rather than the human eye.

IX.5 LIGHTING.

A. New Buildings. More appropriate lighting levels for new buildings are relatively easy to achieve. Most lighting engineers could design a good system to the levels proposed here even more easily than they can provide the more traditional higher intensities - at about 1/2 the cost.

The use of natural light is valuable because as little as 1/4 as much heat per fc as fluourescent lights will be brought into the building. Fewer engineers will be familiar with natural lighting yet there is an extensive literature that will be of value.

Design and placement of windows and skylights is of utmost importance. In a hot dry climate like Indio the use of reflected sunlight rather than direct sunlight is desirable. Skylights should be double or triple glazed and properly oriented.

Artificial lights must be chosen with great care because of the heat generated by lights. Although this is useful on cool winter days* it is expensive in the summer. Every watt of light adds another 3.41 BTU's of heat. As the case studies will show this can become a significant factor in an overlit building. Every 40 one-hundred watt bulbs can require another ton of air conditioning - and in some cases this may increase the peak power demand requiring development of another 2 kilowatts of generating capacity. A maximum of 3/4-1 watt/square foot will suffice for lighting standard buildings (down from 4 or 5 watts per sq.ft., so common 5 years ago). Natural lighting used properly can almost completely eliminate the use of energy for lighting during the daylight hours.

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* *Heating directly with gas or electricity is much more efficient.*

A system with switching and wiring to allow great flexibility is essential to maintain appropriate light levels as area uses change.

IX.6 RETROFITTING EXISTING BUILDINGS. Unfortunately, most of the more recent buildings have been very much overlit, and are poorly oriented for natural lighting. This section examines several principles of retrofitting and then discusses several cases in some detail.

The easiest response to overly bright buildings is simply to remove or turn off lights. In typical buildings a reduction to 1/2 the existing bulbs is commonly a logical first step. Office workers are often pleasantly surprised by the improved comfort. The use of an fc meter is desirable if one is available.

The next step can be more difficult and can begin to cost more money. When sockets are available close to work areas desk lamps can be added and background levels reduced still further. Bulb wattage can be changed and more efficient bulbs can be installed.

RELAMPING OPPORTUNITIES

(All costs are figured at 3 cents per kWh. The annual savings include normal ballast loss).

Change office lamps
(2700 hours per year)

from	to	to save annually
1 300-watt incandescent	1 100-watt mercury vapor	$14.58 (486 kWh)
2 100-watt incandescent	1 40-watt fluourescent	$12.00 (400 kWh)
7 150-watt incandescent	1 150-watt sodium vapor	$70.80 (2360 kWh)

Change industrial lamps
(3000 hours per year)

from	to	to save annually
1 300-watt incandescent	2 40-watt fluourescent	$18.69 (623 kWh)
1 1000-watt incandescent	2 215-watt fluourescent	$48.51 (1617 kWh)
3 300-watt incandescent	1 250-watt sodium vapor	$54.18 (1806 kWh)

Change store lamps
(3300 hours per year)

from	to	to save annually
1 300-watt incandescent	2 40-watt fluourescent	$20.55 (685 kWh)
1 200-watt incandescent	1 100-watt mercury vapor	$ 7.92 (264 kWh)
2 200-watt incandescent	1 175-watt mercury vapor	$20.10 (670 kWh)

The next option includes retrofitting switches and sockets to allow maximum user flexibility. This can be expensive if circuits must be extensively revised. However, it may be very cost effective. Adding skylights might also be considered at this point.

The principle of retrofitting can be better understood through the following case studies, including the Indio City Hall, Riverside County Building - typical office, the Daily News Building, Alpha Beta Market, a shopping mall and finally a look at two homes for an examination of typical light levels of homes.

CASE STUDY: INDIO CITY HALL

The installed lighting in the Indio City Hall totals 4.22 watts per square foot including outside lighting with 3.78 watts per square foot of inside lighting only. Of the 10,000+ square feet of main building 60% of the area of potentially in a perimeter zone that could be lit with natural light. If the design goal of 3/4 watts per square foot is met the total use of electricity will be reduced almost 4 times. This may be difficult to do because of rewiring options and limited use of natural lighting. The following discussion assumes a reduction in energy use of 1/2 for lighting.

Offices 32, 36, and 22 will serve as examples. In room 32, 3.9 watts per square foot were installed and these provide more than 150 fc at the desk top. With half of the 16 bulbs removed the reading dropped to only 90-100 fc. This is still higher than necessary, unless the occupant has limited vision. A reduction to only one bulb per fixture should provide a light level of about 50 fc which is more than adequate. A desk lamp could be provided for the few times during a year when very difficult visual tasks are done.

In room 36 which is a conference room there are 4.27 watts/square foot providing 160 fc with all lights on. With half of the bulbs removed light levels are still quite high. A further reduction to 1/4 of the bulbs would be more appropriate.

Room 22 was even brighter. With 4.06 watts/square foot installed it was extremely bright. With 1/2 of the bulbs removed 140 fc were still received at the table top.

In many perimeter offices all lights can be turned off on bright days. The daylight potential would have been better if the building designer had been more conscious of the energy price increases. However, there is still much that can be done.

INDIO CITY HALL LIGHTING LEVELS
DAYLIGHT POTENTIAL

Clear Day Readings	Lights on/ Shade Normal	Lights off/ Shade	Lights off/ Shades open
Offices			
Room 33	100	14	14
Room 34	150	30	30
Room 36	70	15	15
Room 49 (near window)	100	10	39
(near 2nd desk)	150	7	8
(near water)	150	5	5
Room 52	160	30	100
Room 50	150	9	20

The council chambers were also evaluated. Good flexibility was designed into the system and light levels at the lowest setting were very reasonable. In a test run at the chamber no comments were received about the "dimly" lit room.

The City Hall lobby was also evaluated with various light systems off. Light levels were very reasonable with overheads, soffit, and cove lights out. However, task lights should be provided if the lower levels are maintained.

The system can be greatly improved by reducing lighting by 1/2 - 1/4 of current levels. Some heating of transformers will result and the empty transformers should be disconnected where possible.

The savings resulting from this reduction can be estimated through an analysis of current use. Estimated monthly use at 5 days/week, 22 days/month, 10 hours/day, all lights on.

43.04 KW of lights x 10 hrs/day x 22 day/month = 9468 KWH/mo

This appears very reasonable when compared to actual utility bills.

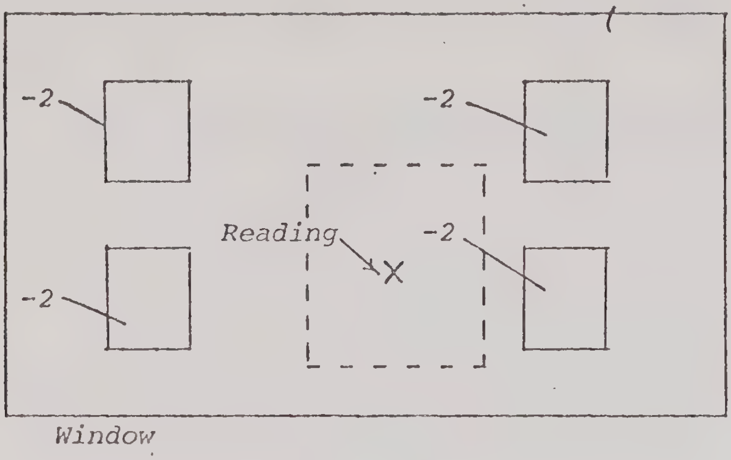
	Electricity		Gas	
10-20			28	$ 7.48
10-15	32,160	$526.36		
11-19			27	12.65
11-14	24,800	329.76		
12-19			609	81.85
12-12	15,360	204.29		
1-22			622	84.06
1-15	17,440	367.99		
2-23			669	87.80
2-13	18,080	388.72		
3-23			393	53.02
3-12	16,320	350.88		

ENERGY BILLS INDIO CITY HALL 1975-76

If lighting is reduced by 1/2 the use can be reduced from 9468 to 4734 KWH. This would result in a saving of more than $100/month in the winter. If the level can be reduced to 1/4 of current use, savings of almost $150 could be realized in the winter. This reduction in lighting will increase the use of gas for heating by about 14 therms, or about $2.00 - $4.00.

In the summer, the savings would be even greater because the cooling load would be reduced. If light levels are reduced by 1/2 the heat load on the building can be reduced by 27,000 BTU/hr. This represents about 2 tons of air conditioning and energy use of about 4 KW/hr. Over a hot summer month this might represent: 4KW/hr x 10 hr/day x 22 days/month = 880 KWH/mo or about $20/month.

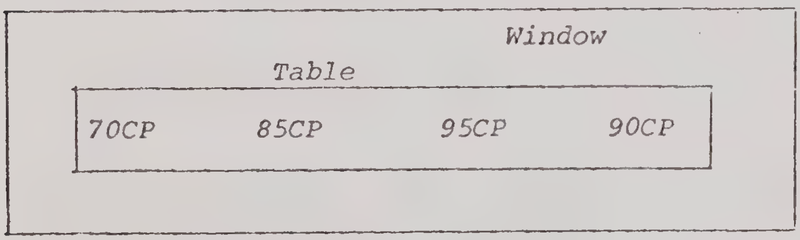
Room 32 has 4 fixtures, each has 4 - 40 watt lamps. The daytime reading at 10 a.m., December 9th was 160 CP at desk top. We removed lamps and took readings as follows:



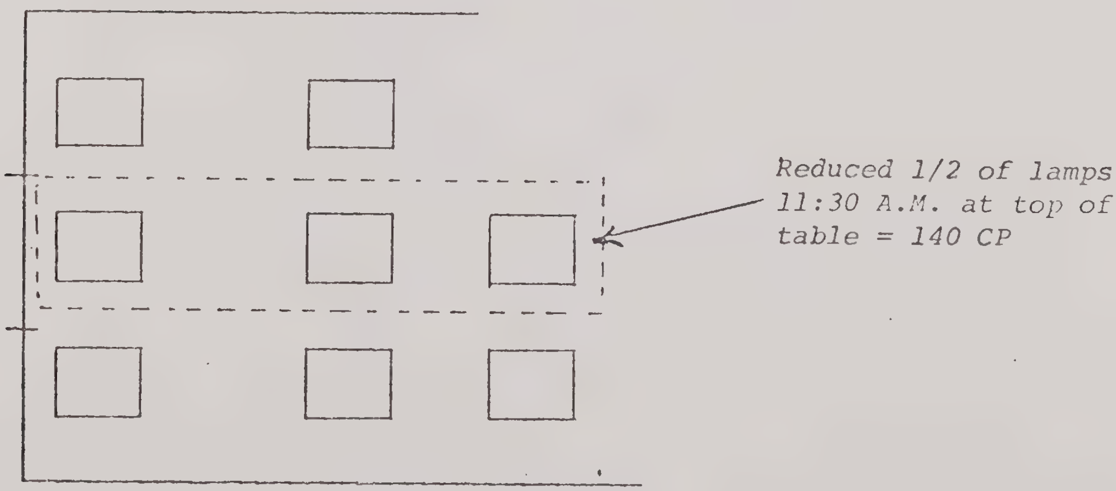
bulbs dropped
-2 = 140 CP
-4 = 130 CP
-6 = 110 CP/100 CP nighttime
-8 = 90-100 CP

Room 36. Conference Room, north side.

9 p.m. - 160 CP, full lights, December 8th.
11 a.m. - 1/2 of bulbs removed (2 per fixture)



Room 22.



Other Examples.

A typical office in the Riverside County Building is also overlit - yet not quite as much as the City Hall. Here a light reduction of only 1/2 would be satisfactory.

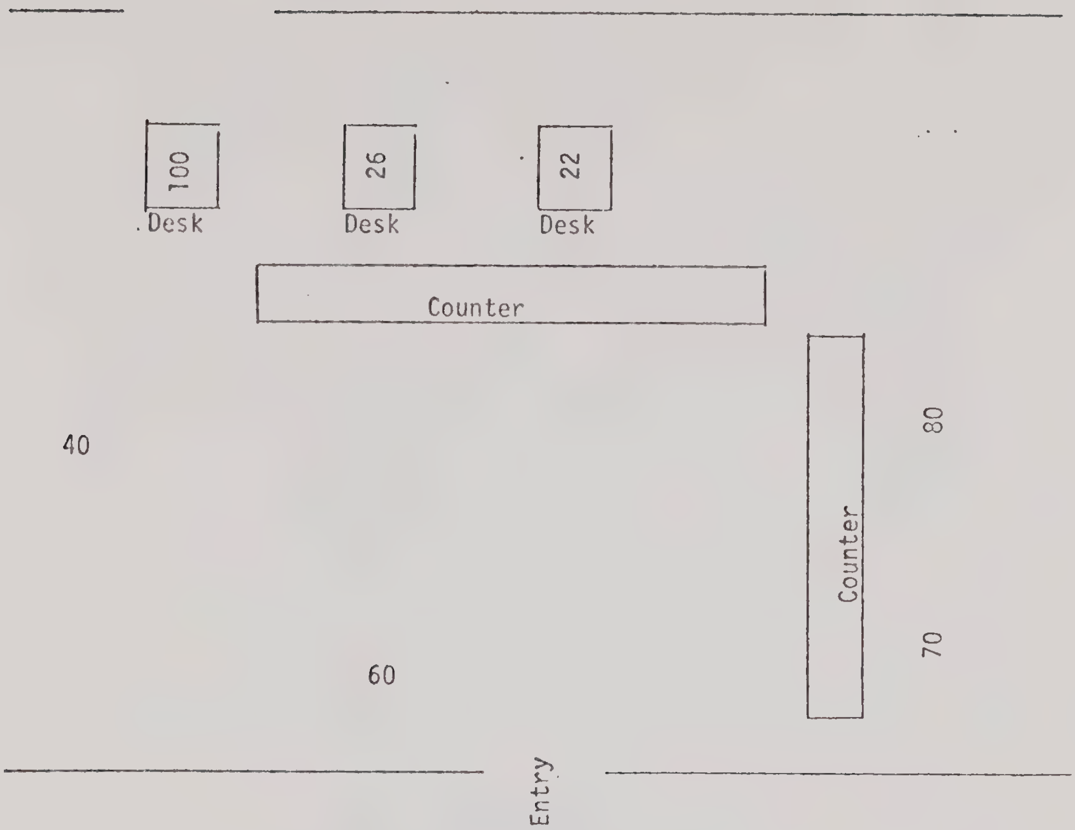
The Alpha Beta market is also overlit, though not as badly. The general level could be reduced by about 1/2, however, the checkout stand lighting must provide good task lighting for reading prices.

The light level in the Daily News Building is more appropriate, yet light levels might be reduced by about 1/2 if task lights were provided.

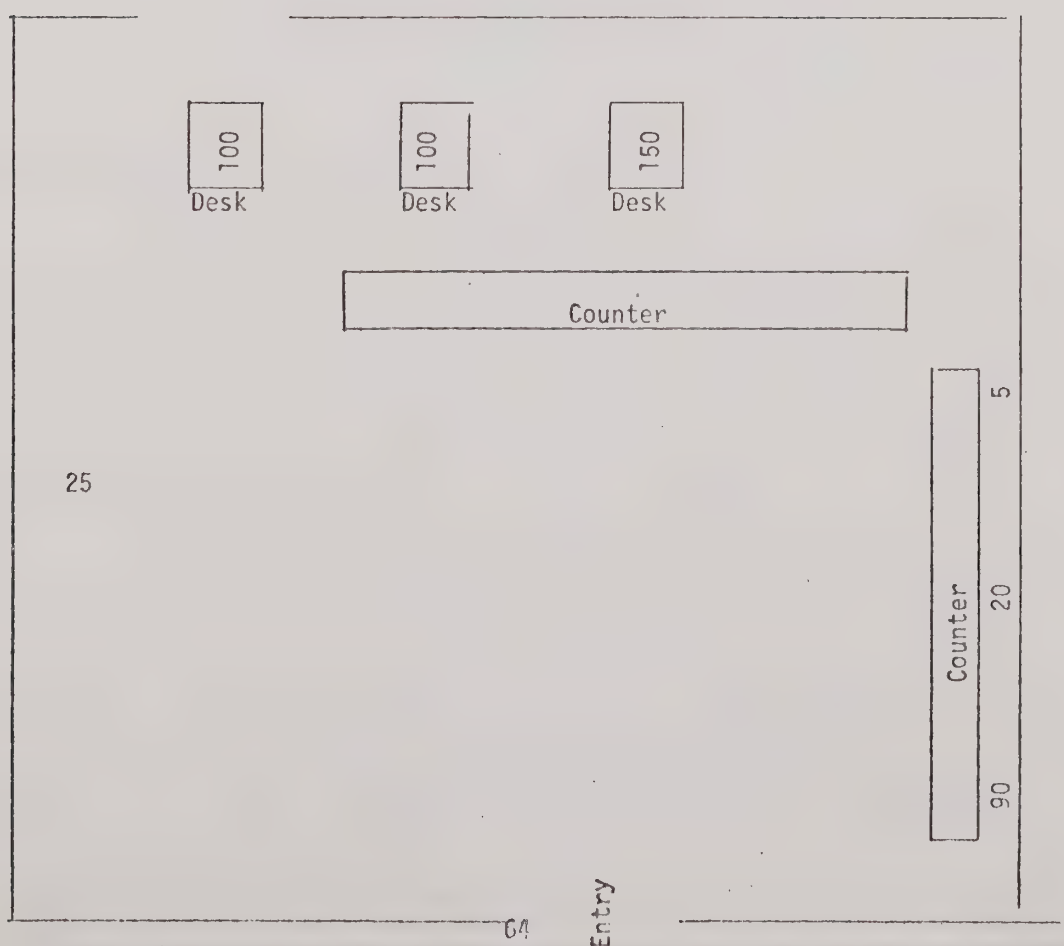
The light levels in the two homes tested reveal more clearly what human needs really are. General light levels are commonly below 10 fc. Reading is commonly done with 12 fc or less without discomfort. The lessons learned at home can be applied to the office.

And finally, a brief survey of the shopping mall revealed excessive lighting levels in most shops and stores. The Sears store had the most appropriate lighting levels as a result of energy conservation measures. According to a Sears representative energy use had been cut by more than 30% in two years.

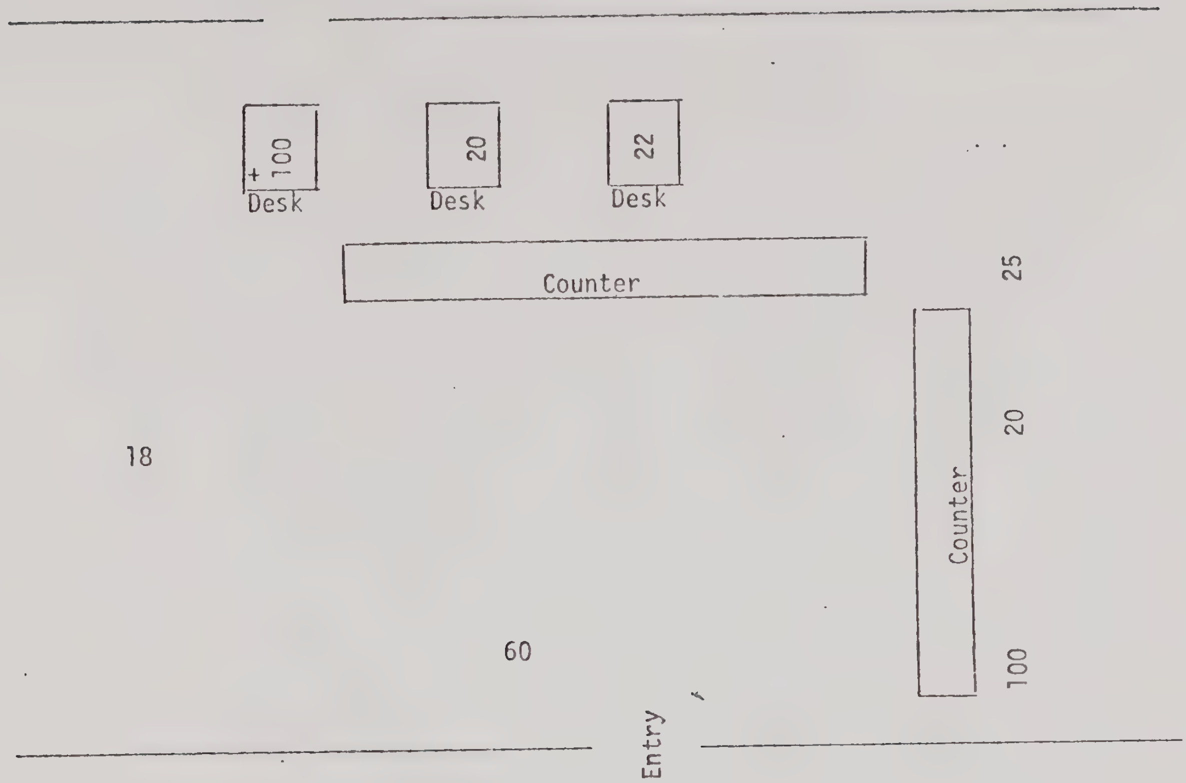
City Hall Lobby
With
Overheads Out
(All readings in foot candles)



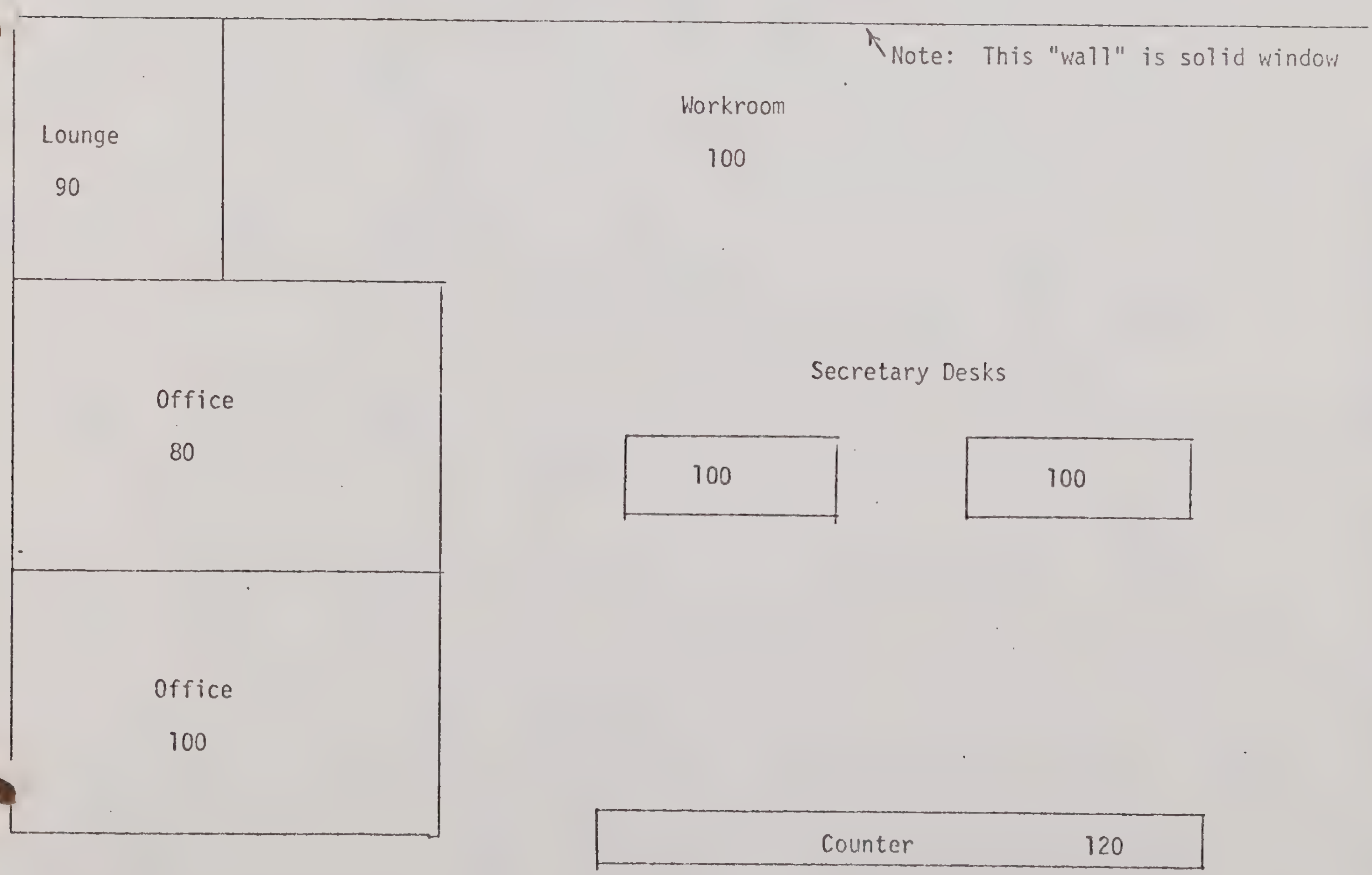
City Hall Lobby
With
Soffitt Lights Out
Cove Lights Out
(All readings in foot candles)



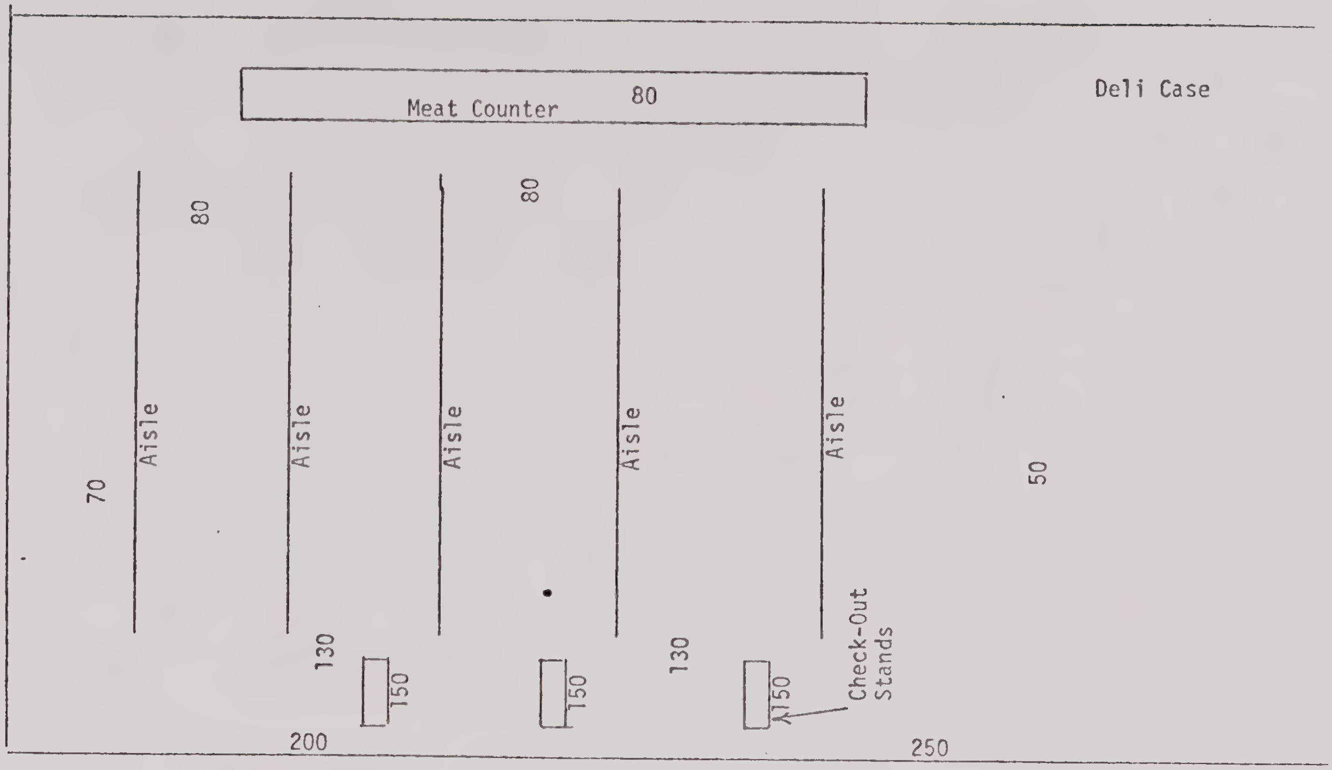
With
Overhead Lights Out
Soffitt Lights Out
Cove Lights Out
(All readings in foot candles)



Typical Office
Riverside County Building
(All readings in foot candles)

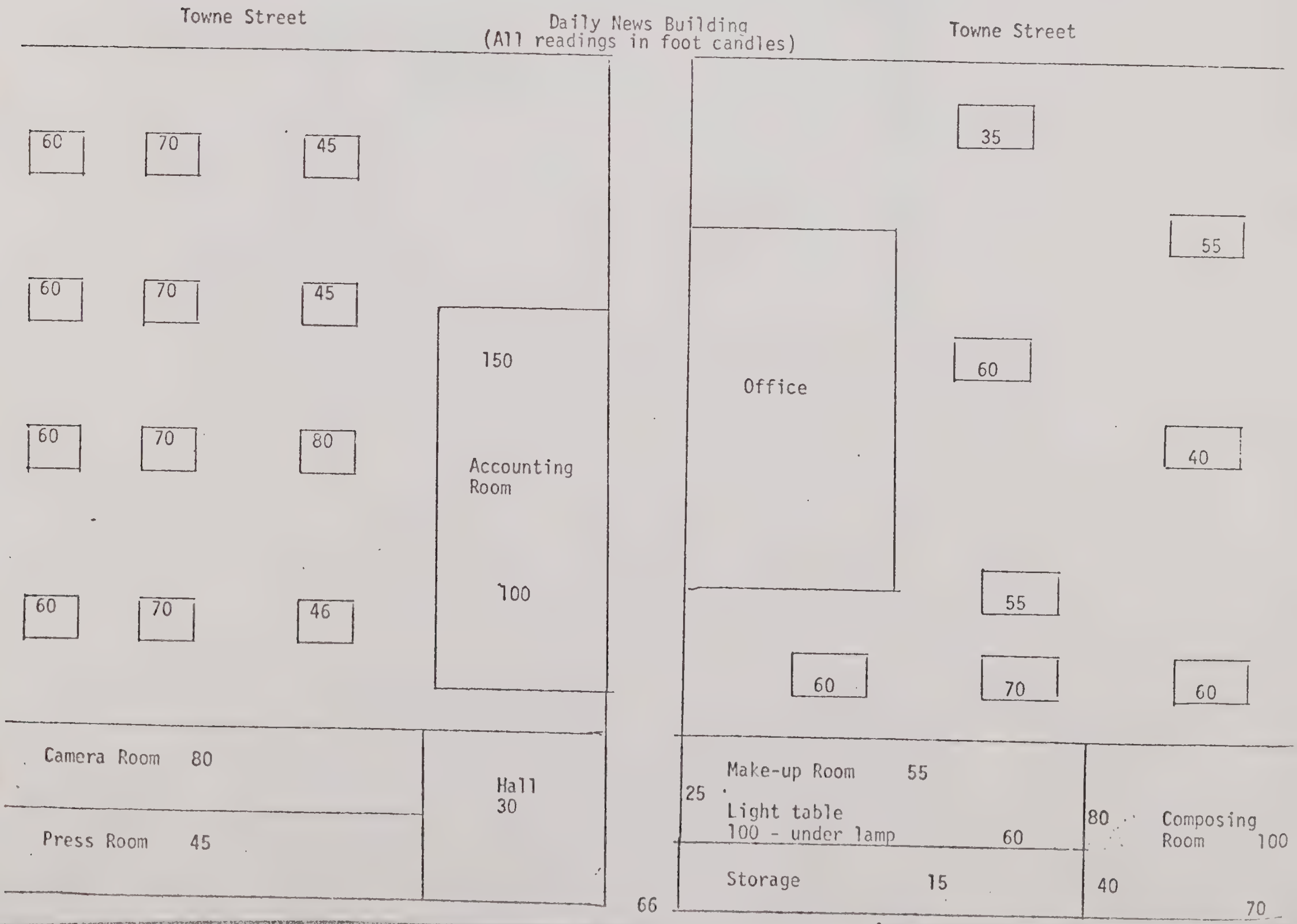


Alpha Beta Market
(All readings in foot candles)



This "wall" is solid window

Daily News Building
(All readings in foot candles)



Northrup's home, December 8th, 10:00 p.m.

Location	Reading
- In reading chair in living room under 100W lamp.	10
- Under 75W "spot" swag lamp at couch	12
- Dining Room Table	12
- Kitchen counter	6
- In front of bathroom mirror - chest high	45
- Reading level under bedroom lamp	6
- 30" under kids room ceiling light	14
- General lighting for family room	4

Jon Dittmer's Home, Evening

Location	Reading
- Front of mirror: Bath #1	45
Bath #2	40
- At dining room table	50
- TV Room (general)	15
- Living room (general)	7
- Kitchen (general)	15
- Bedroom (general)	7

December 4, 1975, 8:45

Shopping Mall Light Levels	fc
- Thrifty	between 60-80
Thrifty outside near entrance	35-40
- Harris' entrance outside	7-15
Harris' inside	30-60 (50 average)
- Side corridor of Mall	(± 10) varies 5-30 under spots 100
- Kenmore's Shoes	50-100
- The Out Post up to 100	(60 average)
- Hartfields	10-50 (30 average)
- Karl's Shoes	30-50 (45 average)
- Bob's Old Fashioned Ice Cream on counter (lady behind counter will put in smaller bulbs after originals burn out. Too hot in summer)	80-100
- Zales Jewelry	top counter 300 30-100 (50 average)
- Sears - furniture section (set for home view)	12 with spots
Floor covering, towels	30
General Display	40 50+

Almost all shops could reduce lighting from 1/2 or 1/ the current level.

ORDINANCE NO.

AN ORDINANCE OF THE CITY COUNCIL OF THE CITY OF INDIO, CALIFORNIA, RESTRICTING USE OF GAS, ELECTRIC, OIL, PROPANE, KEROSENE, GASOLINE, OR BUTANE SWIMMING POOL HEATERS.

The City Council of the City of Indio, California, hereby ordains as follows:

I

FINDINGS

A. In view of the decreasing supplies of energy in general, and the natural gas in particular, the State Public Utility Commission is considering action to ban the use of natural gas for pool heating.[1]

B. Other types of heaters cause greater use of energy and greater environmental impact due to decreased system in efficiency and incomplete combustion and are therefore worse than natural gas heaters.[2]

C. Solar heating for swimming pools is proven and lifecycle cost are lower than for other systems.

NOW, THEREFORE, THE CITY COUNCIL OF THE CITY OF INDIO, CALIFORNIA, DOES HEREBY PROHIBIT INSTALLATION OF GAS SWIMMING POOL HEATERS UNLESS THEY UTILIZE SOLAR ENERGY.

PASSED, APPROVED and ADOPTED this day of , 1977, by the following vote, to wit:

AYES:

NOES:

ABSENT:

____
Mayor

ATTEST:

__________________________, City Clerk
City of Indio, California

1 *PUC Order No. 1514 (new under revision).*
2 *Steinhart, C. & J. (1975) Energy, Duxbury Press.*
3 *Hammond (1974) A Strategy for Energy Conservation, Living Systems, Winters.*

ORDINANCE NO.

AN ORDINANCE OF THE CITY COUNCIL OF THE CITY OF INDIO, CALIFORNIA, ALLOWING WIDER EAVES TO REDUCE COOLING BILLS.

The City Council of the City of Indio, California, hereby ordains as follows:

I
FINDINGS

A. Shading walls and windows is important if heat gain and cooling bills are to be reduced.[1, 2]

B. Current code restricts eave and canopy width to less than optimal distance.

II
AMENDMENT

Now, therefore, the City Council of the City of Indio, California, does hereby amend Section 25.106 to read:

> "Architectural features such as fireplaces and cornices may extend not more than one third of the required yard or three feet whichever is less." Eaves and canopies may extend not less than 30" from the lot line, unless the neighboring house is 6 feet or more from the lot line when a zero lot eave is allowed, subject to Section 25.22 (D).

PASSED, APPROVED and ADOPTED this day of , 1977, by the following vote, to wit:

AYES:

NOES:

ABSENT:

RAYMOND M. RINDERHAGEN, Mayor
City of Indio, California

ATTEST:

SAUNDRA L. JUHOLA, City Clerk
City of Indio, California

---

1 Hammond, J. et al (1974) A Strategy for Energy Conservation, Living Systems, Winters, California.

2 Neubauer, L. W. (1959) Cooling Principals for Buildings, Agricultural Engineering Department, University of California at Davis.

ORDINANCE NO.

AN ORDINANCE OF THE CITY COUNCIL OF THE CITY OF INDIO, CALIFORNIA, INCREASING SETBACK FLEXIBILITY AND ALLOWABLE DENSITY.

The City Council of the City of Indio, California, hereby ordains as follows:

I
FINDINGS

A. Current design and planning practices encourage wasteful use of space with narrow side yards, ornamental large front yards, and fairly small backyards.

B. Lots are large and encourage sprawl, which increase the area covered with pavement increasing heat problems. This also increases travel time, distance, energy use, and removes land from agricultural use.

C. Commonwall design can decrease cooling load and increase fire safety. Commonwall design also increase efficiency of land use.[1]

D. Courtyard home designs* are appropriate in the desert climate[2], yet are made difficult by setback requirements.

E. Compact design is most appropriate for the hot-arid climate[3] and is discouraged by existing minimum lot size and setback requirements.

F. Proper orientation of houses can reduce yeat gain during the summer and reduce yeat less in the winter.

II
ESTABLISHING NEW SETBACK & LOT SIZE REQUIREMENTS

Now, therefore, the City Council of the City of Indio does amend: Section 25.45.

A. Minimum lot size 3,000 square feet.

B. Building site width 30 feet.

D. Front yard 3 feet.

E. No side or rear yard required for non-dwelling structures. No side or rear yard required for dwellings if a central courtyard or light shafts are provided.

For dwellings without a central courtyard or light shafts, a 15 foot yard is required, to the rear or to one side. One-hour firewall is required on "0" lot line walls.

Garages and carports may begin at the front yard setback.

---

1 *Hammond et al, (1974), A Strategy for Energy Conservation, Living Systems, Winters, CA.*
2 *Olgyay, V. (1963) Design with Climate, Princeton University.*
3 *Givoni, B. (1969) Man, Climate, and Architecture, Elsevier.*

* *A courtyard should be twice as high as wide for maximum effectiveness.*

Section 25.19. Lot Area.

Add: R-1-4 (3,000 sq.ft.) 700 sq.ft. minimum house size

R-1-2 (2,000 sq.ft.) 600 sq.ft. minimum house size

Section 25.20. Lot Width.

Add: R-1-4 30 ft.

R-1-2 30 ft.

Section 25.21. Front Yard.

R-1-6 3 ft.

R-1-4 3 ft.

R-1-2 3 ft.

The minimum setback for the face of a garage or carport shall be the same as for the front yard.

Section 25.22. Side yard.

C. R-1-6, R-1-4, R-1-2. One side 4 ft., total both sides fourteen feet.

D. Zero side yard developments are encouraged and will be permitted by the planning commission in the zones cited in this article, providing property covenants, conditions and restrictions are agreed upon and recorded. When proposed in an existing subdivision a conditional use permit shall be required.

Section 25.23. Rear Yard.

Rear Yard Requirements.

A. R-1-15, R-1-10, R-1-8 10 ft. minimum

B. R-1-6, R-1-4, R-1-2 6 ft. minimum

C. Zero rear yard development is encouraged and will be permitted in the zones cited in this article as per Section 25.22.

Section 25.30. Minimum Lot Requirement.

Minimum lot requirement shall be as follows:

A. Lot Area 3,000 square feet

B. Lot Width 30 feet

C. Setbacks.

1. Front yard, 4 ft.
2. Side yard (as per Section 25.22)
3. Rear yard (as per Section 25.23)

Section 25.37. Lot Width.

Lot Width shall be no less than 30 feet.

Section 25.38. Front Yard.

The front yard shall be no less than 3 feet.

Section 25.39

One side shall be five feet, the total of both sides shall be 15 feet. However, zero lot line will be permitted as per the provisions of Section 25.22 (D).

Section 25.40. Rear yard.

The rear yard shall be one half the height of the building unless a zero lot line is developed subject to the provisions of Section 25.22.

PASSED, APPROVED and ADOPTED this day of , 1977, by the following vote:

AYES: Councilmen

NOES:

ABSENT:

______________________________, Mayor
City of Indio, California

ATTEST:

______________________________, City Clerk
City of Indio, California

ORDINANCE NO.

AN ORDINANCE OF THE CITY COUNCIL OF THE CITY OF INDIO, CALIFORNIA, DE-REGULATING FENCE SETBACK AND CONSTRUCTION IN INDIO.

The City Council of the City of Indio, California, herebo ordains as follows:

I
FINDINGS

A. The people of California face the likelihood of energy and resource short-falls as competition for scarce resources increases.[1,2]

B. Regulation of personal property and behavior is becoming increasingly bur-densome.

C. Increasing use of developed land can reduce demands on resources and energy by reducing conversion of agricultural land[3] and reducing travel distance and time. Fences can provide privacy to allow better natural ventilation, solar heating in winter through south windows, and more intensive use of property.[4]

D. Private garden front courtyards can with good design provide a cool micro-climate entry way which helps keep the house cooler.

E. Complaints over untidy lawns can be easily eliminated if front fences are allowed.

F. Full inspection of every fence modification would be complex and would cost extra money in a time of tightening budgets.

II
FENCES DEREGULATED

Therefore, the City Council of the City of Indio does hereby amend:

Section 25.108.

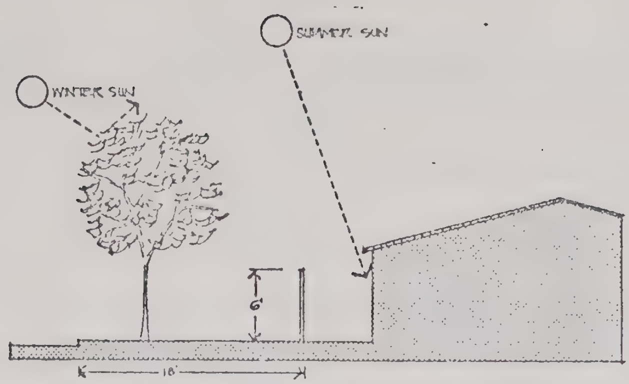
Fences, hedges, or walls not exceeding seven feet in height may occupy and por-tion of a side, rear, or front yard; provided, however, that any fence on a corner lot at an intersection without stop signs or signal controls shall comply with Section 25.109.

Section 25.24-A.

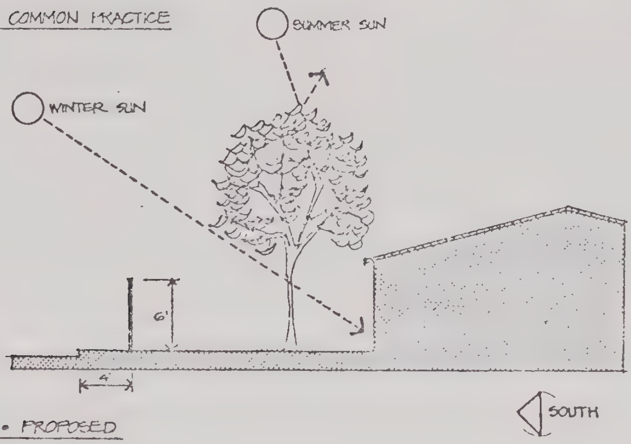
Delete "fences."

---

1 Meadows, Meadows, Randers & Behrens (1973) The Limits to Growth, Potomac.
2 Ehrlich, P. and Ehrlich, A. (1974), Population, Resources and Environ-ment, Doubleday.
3 Assembly Bill 15, "Agricultural Land Protection," Assemblyman Charles Warren (1976).
4 Hammond J. et al. (1974) A Strategy for Energy Conservation, Winters.



FENCES • COMMON PRACTICE



FENCES • PROPOSED

PASSED, APPROVED and ADOPTED this   day of   , 1977, by the following vote:

AYES:

NOES:

ABSENT:

________________________, Mayor
City of Indio, California

ATTEST:

________________________, City Clerk
City of Indio, California

ORDINANCE NO.

AN ORDINANCE OF THE CITY COUNCIL OF THE CITY OF INDIO, CALIFORNIA, AMENDING SECTION 25.120(C) TO REQUIRE SHADING FOR PARKING LOTS.

The City Council of the City of Indio, California, does hereby ordain as follows:

I
FINDINGS

A. Parking lot shading can provide economic and energy benefits. Maximum temperatures can be kept 10 degrees F cooler with tree shade and evaporative cooling due to transpiring leaves.

B. Lower air and surface temperatures reduce the heat load on buildings significantly and the difference in temperature from inside to outside is reduced. A 10 degree F reduction from 110 degrees to 100 degrees F represents almost a 30% reduction in heat load and a 40-50% reduction in the use of energy for air conditioners.

C. Lower air temperatures and surface temperatures reduce the thermal stress on people as well and encourages bicycling and walking - the only really energy efficient forms of transportation.

D. Lower air and surface temperatures and reduced radiation also lessens the thermal stress on automobiles in parking lots reducing use of air conditioners and thus increasing the efficiency of the auto.

E. Existing landscaping was often chosen for ornamental rather than functional reasons and provides little microclimate improvement.

II
SHADING REQUIRED

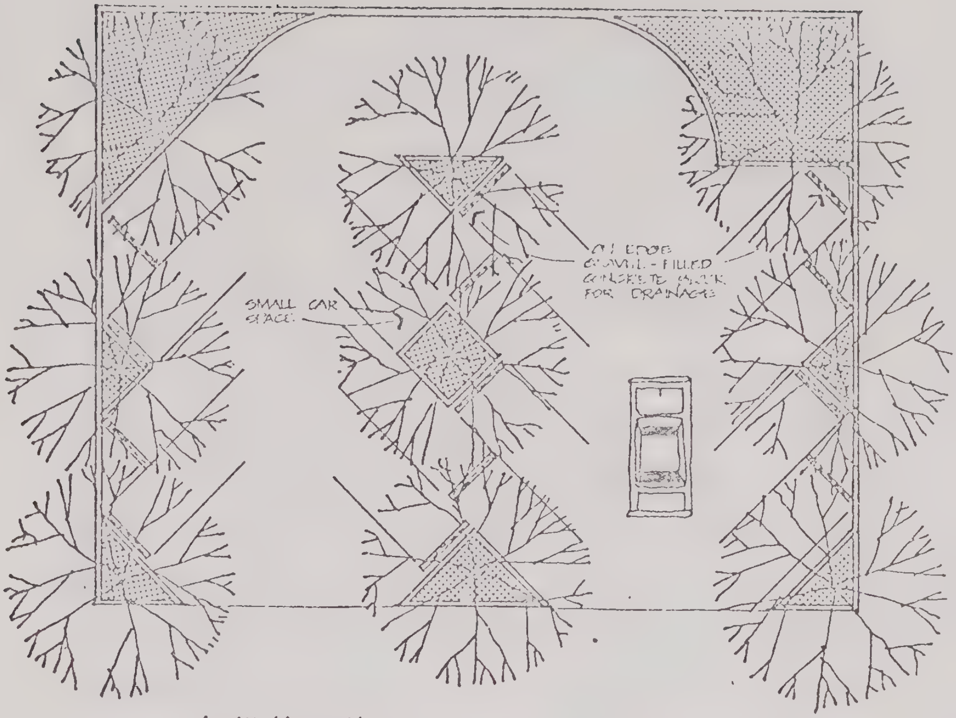
Now, therefore, the City Council of the City of Indio does hereby amend Section 25.120 (C).

"Adequate landscaping shall conform to the following minimum standards."

Tree planting shall be designed so that a minimum of 50% of the parking area will be shaded at noon on August 21 within 51 years of the planting. This can be calcualted by: 1) drawing area that will be covered by drip lines in plain view or by 2) actually casting of the shadows cast by the trees and surrounding structures at noon using a solar altitude of 70 degrees due south.

Trees used for this purpose most meet the following criteria:

1. Cast moderate to dense shade in summer.
2. Long lived - over 60 years.
3. Does well in an urban environment.
   a. Pollution tolerant.
   b. Tolerant of direct heat and reflected heat.
4. Little maintenance.
   a. Mechanically strong.
   b. Insect and disease resistant.
   c. Requires little pruning.
5. Able to survive one year with no irrigation after establishment.



A WELL-SHADED PARKING LOT

Deleting: "Interior planting: One ten-gallon broad leaf or conifer for each lot space, for which 25% may be substituted with palm trees with not less than six feet of trunk."

PASSED, APPROVED and ADOPTED this day of , 1977, by the following vote, to wit:

AYES:

NOES:

ABSENT:

______________________________, Mayor
City of Indio, California

ATTEST:

______________________________, City Clerk
City of Indio, California

RESOLUTION NO.

A RESOLUTION OF THE CITY COUNCIL OF THE CITY OF INDIO, CALIFORNIA, SUPPORTING INCREASED TREE SHADING IN EXISTING DEVELOPMENT.

WHEREAS, the City Council has realized the energy and economic benefits of shady streets and parking lots; and

WHEREAS, most existing streets and parking lots in Indio are undershaded and would benefit from further shading; and

WHEREAS, the City can set a positive example for the rest of the community by bringing existing streets and parking lots up to the new standard where existing planting will not meet the 50% requirement in 15 years.

NOW, THEREFORE, THE CITY COUNCIL OF THE CITY OF INDIO, CALIFORNIA, HEREBY RESOLVES AS FOLLOWS:

The City Council therefore directs the Public Works Department to develop a plan and budget for tree planting in existing areas of Indio.

And finally, the City Council directs the Planning Commission to require landscaping retrofit of commercial parking lots as a condition to allowing remodeling of the attached commercial space. The intent of the landscape improvements would be to bring the parking lot up to the standards required by the parking lot shading requirements.

PASSED, APPROVED and ADOPTED this day of , 1977, by the following vote, to wit:

AYES:

NOES:

ABSENT:

____________________________, Mayor
City of Indio, California

ATTEST:

____________________________, City Clerk
City of Indio, California

ORDINANCE NO.

AN ORDINANCE OF THE CITY COUNCIL OF THE CITY OF INDIO, CALIFORNIA, REQUIRING FUNCTIONAL LANDSCAPING IN NEW COMMERCIAL DEVELOPMENTS.

The City Council of the City of Indio, California, hereby ordains as follows:

I
FINDINGS

A. Trees, vines, and other landscaping plants provide excellent cooling, particularly if they provide shade on buildings (windows, walls or roofs), sidewalks, and streets.[1-6]

B. Current landscape is often chosen to minimize maintenance cost of landscape without consideration of potential savings for the building as a whole.

II
ORDINANCE

Therefore, the City Council of the City of Indio hereby adds the following to Section 25.50:

All landscape plantings in required landscape areas must be designed to maximize shading of buildings and panel areas.

All developments required to meet provisions of this section shall submit a landscape plan with all landscape plantings drawn accurately both in plan and elevation as they will appear after 10 years, or such other time period as required by the planning department.

PASSED, APPROVED and ADOPTED this day of , 1977, by the following vote, to wit:

AYES:

NOES:

ABSENT:

______________________________, Mayor
City of Indio, California

ATTEST:

______________________________, City Clerk
City of Indio, California

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1 *Neubauer, L. N. (1970) Optimum Alleviation of Solar Heat Stress on Model Buildings, ASAE paper 70-401.*

2 *Hammond et al (1974) A Strategy for Energy Conservation, Living Systems, Winters.*

3 *Olgyay, V. (1963) Design With Climate, Princeton, Univ.*

4 *Landsberg, H. (1947) "Microclimatology for Planners," Architectural Forum, March.*

5 *Geiger, R. (1965) The Climate Near the Ground, Harvard Univ.*

6 *Deering, R.B. and Brooks, F.A. (1954), "The Effects of Plant Material Upon the Microclimate of House and Garden," National Horticultural Magazine, Julu.*

RESOLUTION NO.

A RESOLUTION OF THE CITY COUNCIL OF THE CITY OF INDIO, CALIFORNIA, SUPPORTING FURTHER DEVELOPMENT OF BIKEWAYS AND BICYCLE FACILITIES TO ENCOURAGE BICYCLISTS IN INDIO.

I

FINDINGS

A. The people of the City of Indio face increasing environmental polution caused in large part by the automobile.[1]

B. The use of energy in transportation reduces the energy available for electrical generation and contributes to increasing sensitivity to disruption of supply.[2]

c. The bicycle is the most energy efficient form of transportation[3,4] and produces no environmental pollutants. In addition, the bicycle is inexpensive to operate and available to most citizens who cannot afford an automobile.[5]

D. The bicycle will not be used widely unless steps are taken to provide improved routing , support facilities (racks, etc.) , and improved microclimate to extend the bicycling season.

NOW, THEREFORE, BE IT RESOLVED BY THE CITY COUNCIL OF THE CITY OF INDIO, CALIFORNIA, THAT:

The City of Indio shall support development of the bikeway system and supporting facilities.

In addition, the City Council supports the new EIR requirements concerning bicycle circulation.

And finally, the City Council commends the many citizens who devoted their time to the preparation of the Indio Bicycle Plan and who ride their bicycles. By doing so they make Indio a nicer place to live for all others.

PASSED, APPROVED and ADOPTED this day of , 1977, by the following vote, to wit:

AYES:

NOES:

ABSENT:

---

1 Schneider, K. (1972) Autokind vs. Mankind, Scliskern.
2 Clark, W. (1975) Energy for Survival, Androc.
3 Wilson, D. (1973) "Bicycle Technology," Scientific American, March.
4 Hirst, E. (1974) Energy Use for Bicycling, ORNL-NSF-EP-65, Oak Ridge.
5 Illich, I. (1974) Energy and Equity, Perennial Library.
6 Sommers, R. and Lott, D. (1972) "The Davis Experience," (mimeo.)
7 Bainbridge, D. and Moore, M. (1974) Bikeway Planning & Design: A Primer, Bainbridge, Behrens & Moore, Broderick.
8 Olgay, V. (1963) Design Wity Climate, Princeton.

RESOLUTION NO.

A RESOLUTION OF THE CITY COUNCIL OF THE CITY OF INDIO, CALIFORNIA, SUPPORTING FURTHER DEVELOPMENT OF PEDESTRIAN FACILITIES IN INDIO.

I
FINDINGS

A. The value of walking as an energy conserving, non-polluting form of transportation warrants further consideration of pedestrian planning in existing and future development.

B. Pedestrians require certain types of walkways, signals, and microclimatic factors.[1]

NOW, THEREFORE, LET IT BE RESOLVED BY THE CITY COUNCIL OF THE CITY OF INDIO, CALIFORNIA, THAT:

II

That the Planning & Development Department shall prepare a pedestrian plan for presentation to the City Council by January, 1977. And that this plan will include recommendations for routing, shading, easement acquisition, and such other facilities as the Planning & Development Department deems desirable along with a program to develop these facilities within the city.

PASSED, APPROVED and ADOPTED this day of , 1977, by the following vote, to wit:

AYES:

NOES:

ABSENT:

______________________________, Mayor
City of Indio, California

ATTEST:

______________________________, City Clerk
City of Indio, California

---

1 *Fruin, J. J. (1971) Pedestrian Planning, MAUDEP.*

ORDINANCE NO.

AN ORDINANCE OF THE CITY COUNCIL OF THE CITY OF INDIO, CALIFORNIA, PROHIBITING RESTRICTIVE CONVENANTS OR REGULATIONS THAT BAN USE OF CLOTHESLINES IN MULTI-UNIT DWELLINGS.

The City Council of the City of Indio, California, does hereby ordain as follows:

I
FINDINGS

A. Clotheslines are the most energy efficient method of clothes drying.[1]

B. Concern over aesthetics has on occasion led to bans on the use of clotheslines.

C. Energy to operate electric and gas clothes dryers is increasingly expensive and may become limited.[2]

II
BAN ON CLOTHESLINE RESTRICTION

Therefore, the City Council of the City of Indio does hereby prohibit any rule, regulation, or covenant prohibiting the use of a clothesline in any new residential zone.

III
CLOTHESLINE REQUIRED

And furthermore, the City Council of the City of Indio, does hereby require that all new multi-unit development must provide clotheslines, clothes racks, or similar facilities to enable residents to dry their clothes under the sun. Such clotheslines shall be convenient to washing facilities and oriented to receive sufficient sun to dry clothes throughout the year.

PASSED, APPROVED and ADOPTED this day of , 1977, by the following vote, to wit:

AYES:

NOES:

ABSENT:

________________________, Mayor
City of Indio, California

ATTEST:

________________________, City Clerk
City of Indio, California

---

1 *Ford Foundation (1975) Energy Conservation Papers, Ballinger.*
2 *Rand Corporation (1975) Energy Alternatives for California's Future, Santa Monica.*

RESOLUTION NO.

A RESOLUTION OF THE CITY COUNCIL OF THE CITY OF INDIO, CALIFORNIA, REQUESTING THE STATE LEGISLATURE TO ENACT LEGISLATION REQUIRING ENERGY EFFICIENCY LABELING ON ALL APPLIANCES.

WHEREAS, the City of Indio understands the value of energy conservation in lieu of increasing power production; and

WHEREAS, the use of appliances is intensive in Indio, particularly for air conditioning; and

WHEREAS, it is difficult to choose the most energy efficient appliances when even the distributors do not know the efficiency of their various models; and

WHEREAS, efficiency may vary between 2-3 times for any appliance type; and

WHEREAS, the State Energy Commission is setting only minimum performance standards.

NOW, THEREFORE, THE CITY COUNCIL OF THE CITY OF INDIO, CALIFORNIA, RESOLVES AS FOLLOWS:

That the City Council of the City of Indio requests the Assembly Committee on Energy and Diminishing Resources to introduce legislation requiring energy efficiency ratings (EER) on all major appliances sold in California after January, 1977.

PASSED, APPROVED and ADOPTED this   day of   , 1977, by the following roll call vote, to wit:

AYES:

NOES:

ABSENT:

______________________________, Mayor
City of Indio, California

ATTEST:

______________________________, City Clerk
City of Indio, California

APPENDICES

APPENDIX B

INDIO DATA COLLECTION AND COOL POOL EXPERIMENT

The purpose of the data collection program in Indio was to provide the necessary empirical information for the successful completion of the project. Basic research is expensive under ideal conditions and field research is even more difficult. But field research, even if not exact or basic, is valuable to those involved because it serves to educate their senses. Basic building science research has been carried out in various places throughout the world to produce an extensive body of practical knowledge about how buildings work. As with all engineering data and calculation techniques, educated judgment is needed for efficient and correct application.

Saving energy through energy conservation and natural heating/cooling is dependent upon what is economically viable and attractive. The money people spend on energy during the year is a critical piece of information. Most people have become miles per gallon conscious and are aided in the search for energy savings by EPA testing figures. In order to facilitate public action towards saving gasoline, usage figures for the City's fleet were obtained. The other major areas of energy consumption kept track of were: monthly bills for utilities, natural gas, and electricity. The emphasis in our project was upon residential energy use. Data was obtained from the local utility companies and is reported on in the "Utility Bill Survey" section of this report.

As most people in the Coachella Valley know, their major consumption is electricity for air conditioning. Even though Indio has warm winters, house heating takes 1/2 the energy of air conditioning. Together, space heating and cooling account for more than 1/2 of the total utility bill of a household. The reason is simply that human comfort is maintained by appliances which consume energy because dwelling units can not provide comfort without them. Human comfort is complex but is mostly dependent on the air temperature, radiant temperature, and the humidity. Air temperature is the best integrator of human comfort, actuates thermostats, and is the easiest to measure. Thus, the field research was done with maximum-minimum thermometers, recording thermometers, and, for the cool pool prototype, a multipoint recording thermometer.

The energy use for office buildings and commercial establishments can be high. This is especially true in a hot area where the heat given off by the lighting inefficiency adds substantially to the air conditioning load of the building. A hand-held light meter was obtained and levels of lighting on foot candles were measured. The results are reported on in the "Lighting for Energy Conservation" section of this report.

The instruments listed below were used for field studies.

SIMPLE INSTRUMENT PACKAGE

Instruments Purchased

1.	Max-Min Thermometer "U" Tube Type	Weather Measure TM45	$ 14.00	6
2.	Mercury Thermometer	Weather Measure TM-IF 38/130	$ 10.00	1
3.	Recording Thermograph	Weather Measure Model 611-S	$175.00	1
4.	Illuminating Engineering/ Safety Meter	Photo Research Model ES-300	$160.00	1

Instrument Rented

24-Point Thermocouple Recorder	Esterline-Argus

The Indio Cool Pool Experiment. In the summer of 1976, Living Systems conducted a series of experiments at the Date and Citrus Station in Indio, California, to test the potential for natural cooling in hot areas. These experiments were designed to test a method of natural cooling developed by Living Systems after a careful review of the previous efforts. The work of Loren Neubauer and Harrold Hay was of particular value.

Neubauer's research involved shading for livestock which demonstrated the cooling potential of a shade that provides full shading yet allows north sky cooling and ventilation.

Harold Hay's work on roof tanks with movable insulation was also of value. The results from the Phoenix test house were of particular value because the climate is very similar to Indio. By using flooded roof tanks and movable insulation, very comfortable temperatures were maintained. The principle drawback has been the difficulty of developing an inexpensive insulation system with automatic controls and tracks.

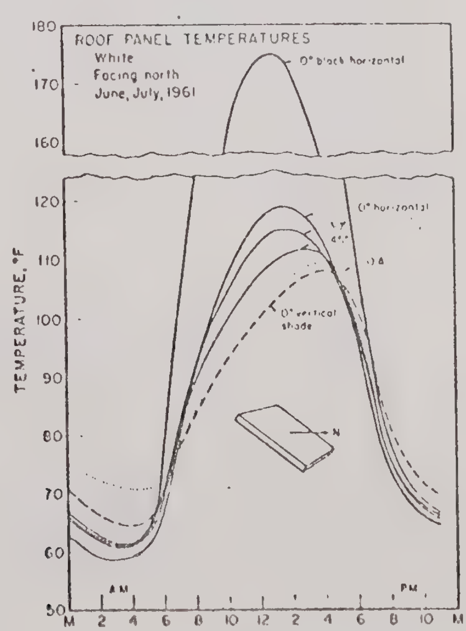
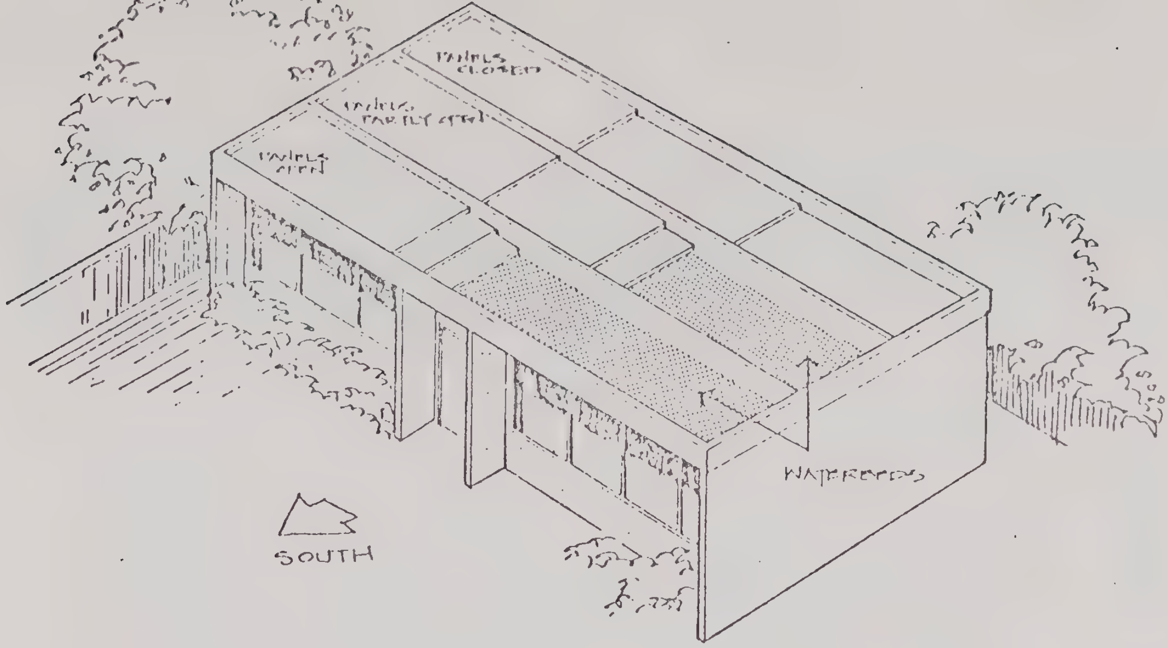
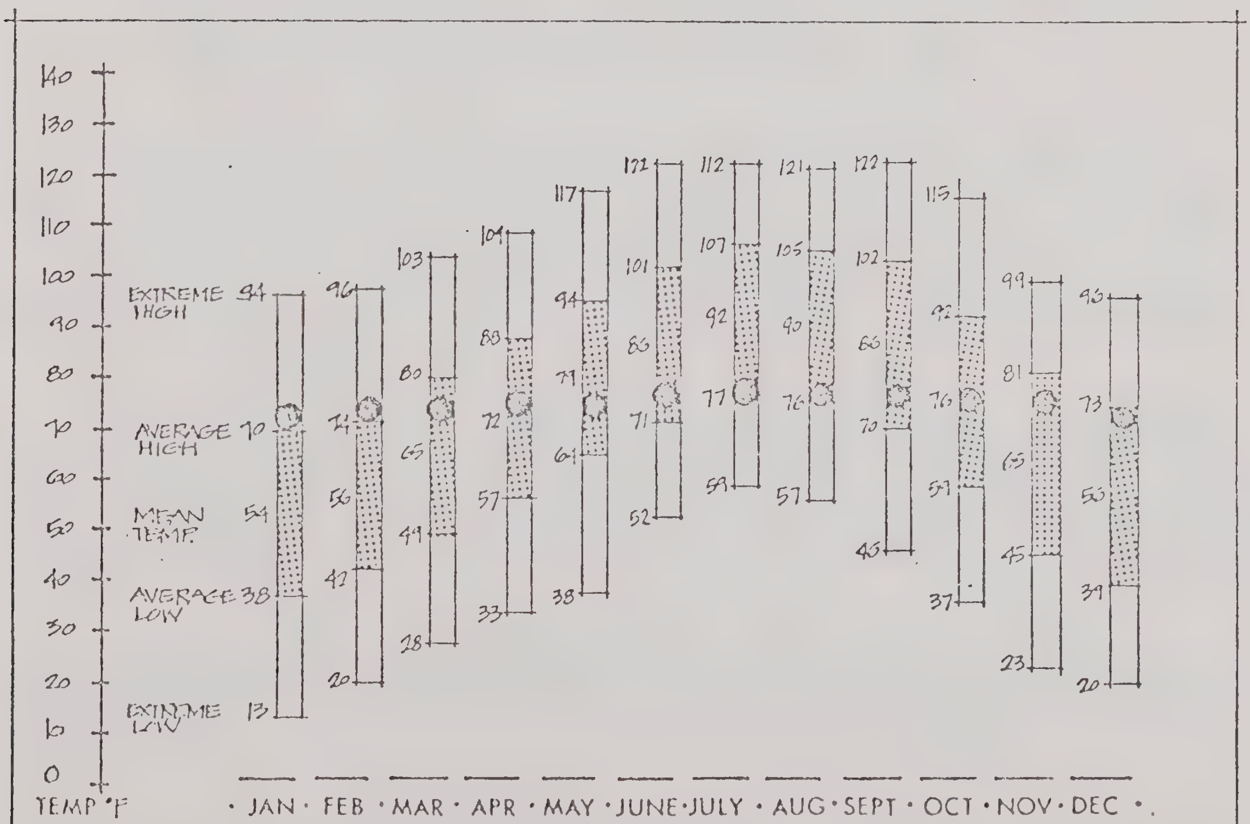


FIG. 7 White roof panels are much cooler than black; coolest when fully shaded.



SKYTHERM HAY HOUSE

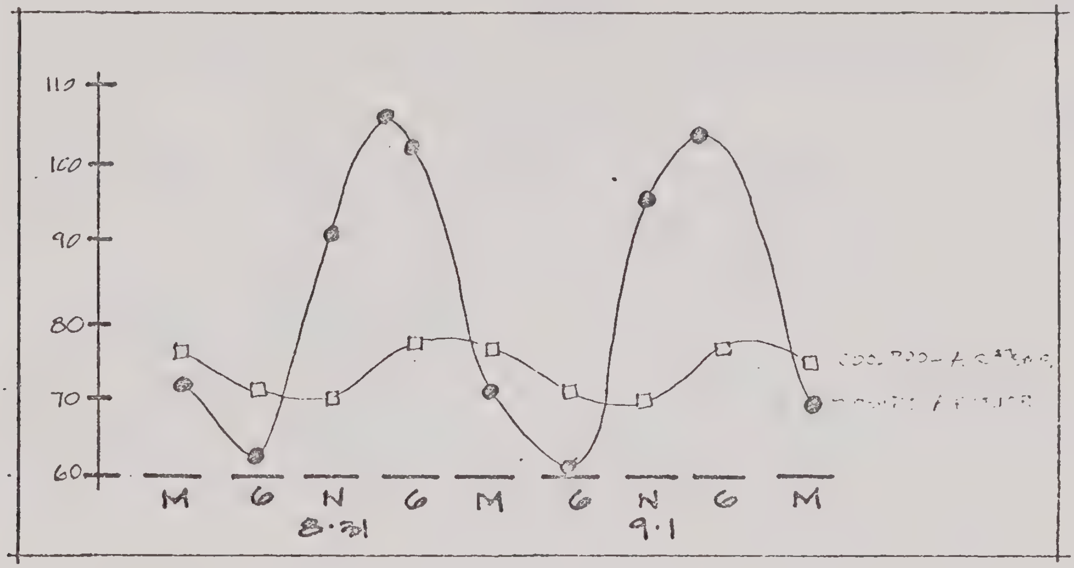
Cooling Mode Operation
Panels opened at night to allow radiant loss from the waterbeds. During extremely hot months the tops of the waterbeds are covered with layer of water to add evaporative cooling. Panels closed during the day.



Performance of Hay Skytherm Prototype Superimposed on Indio Temperature Data

Data adapted from that published by H.R. Hay and J.L. Yellot. Top of dot is the average daily maximum. Bottom of dot is the average daily minimum.

Living Systems conducted several experiments at their office in Winters on the concept of a cool pool. In brief, the cool pool consists of an insulated pool of water, fully shaded from the sun during the day. The pool stays cool primarily by radiating heat to the cool night sky and by evaporation. The results were encouraging and led to construction of a "cool pool" room for the California State Fair in Sacramento.

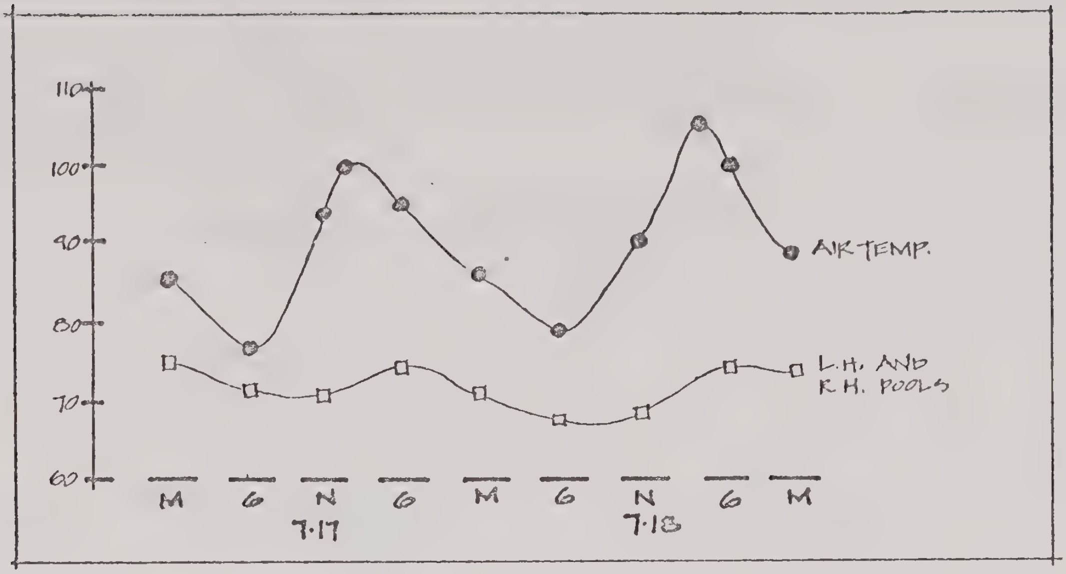


STATE FAIR COOL POOL ROOM · 1976

These results were very encouraging, and Living Systems developed a research program that was conducted at the Date and Citrus Station in Indio during the summer of 1976. Indio is an excellent site for a cool pool, as the summer temperatures are very high yet humidity is very low. In addition, the energy costs in a traditional house are very high, typically as much as $300 a year; and if an economical natural cooling system could be developed, it would very likely be used.

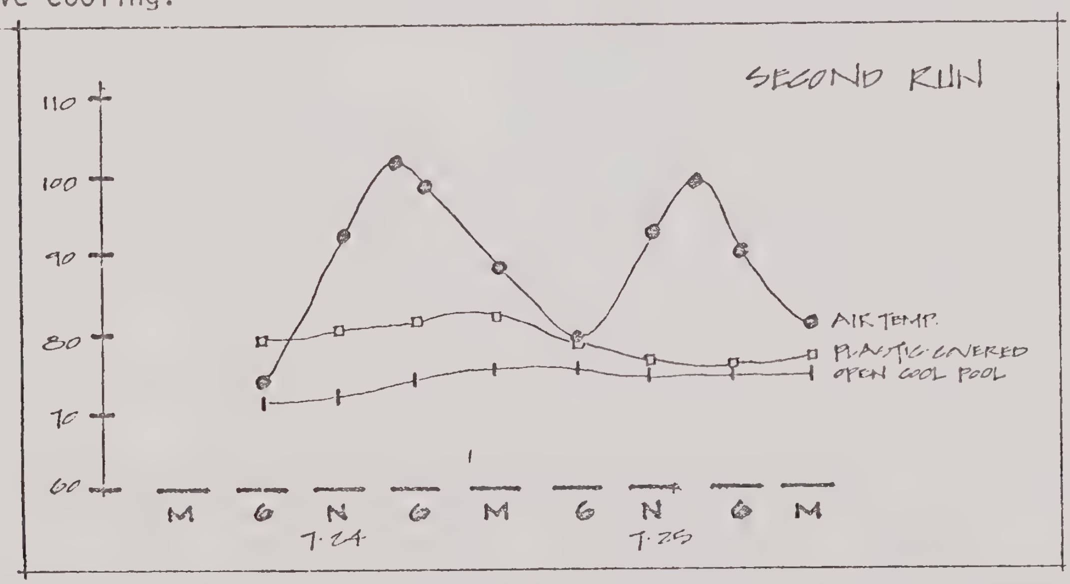
Three experiments were conducted in an effort to assess more precisely how the cool pool worked. The first test used two open pools in an effort to establish a baseline. For the second test, one pool was covered with clear plastic in an effort to establish the importance of evaporation in cooling. And the final test evaluated the cooling ability of the cool pool when a constant heat load is added.

The first experiment was a very useful test and established a good performance baseline. The temperature of the water from the hose was 85^{0}, and the "cool pool" responded quite well, bringing the temperature down in two days to 70^{0}.

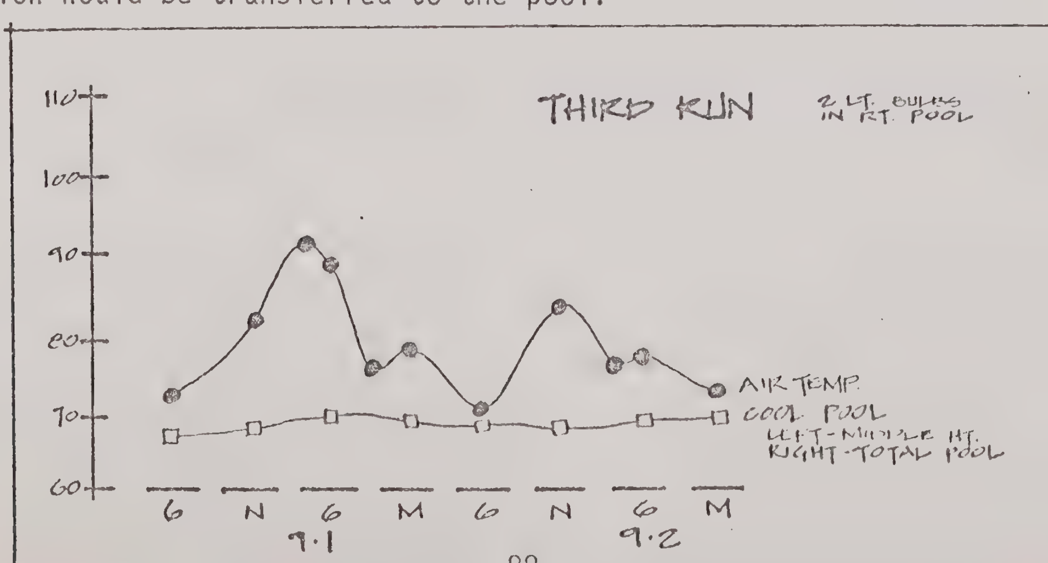


INDIO COOL POOL FIRST RUN

The second test compared a cool pool covered with plastic with an uncovered cool pool. As expected, this revealed the importance of evaporative cooling.



In the final test, a heat source was added to one cool pool to evaluate the cool pool's response to added heat input. The heat source at the bottom of the pool stimulates the operation of a cool pool building where heat from the room below would be transferred to the pool.



The results of this test series were very encouraging. The results are summarized below.

DATA SUMMARY - COOL POOL EXPERIMENTS

	First Run	Second Run	Third Run
Average Air Temperature	93	90	91
Average Cool Pool Temperature	72	74	78
Average Temperature with Plastic Cover on Cool Pool		80	
Average Temperature with Light Bulb Heat Source			78

For Full Experiment:

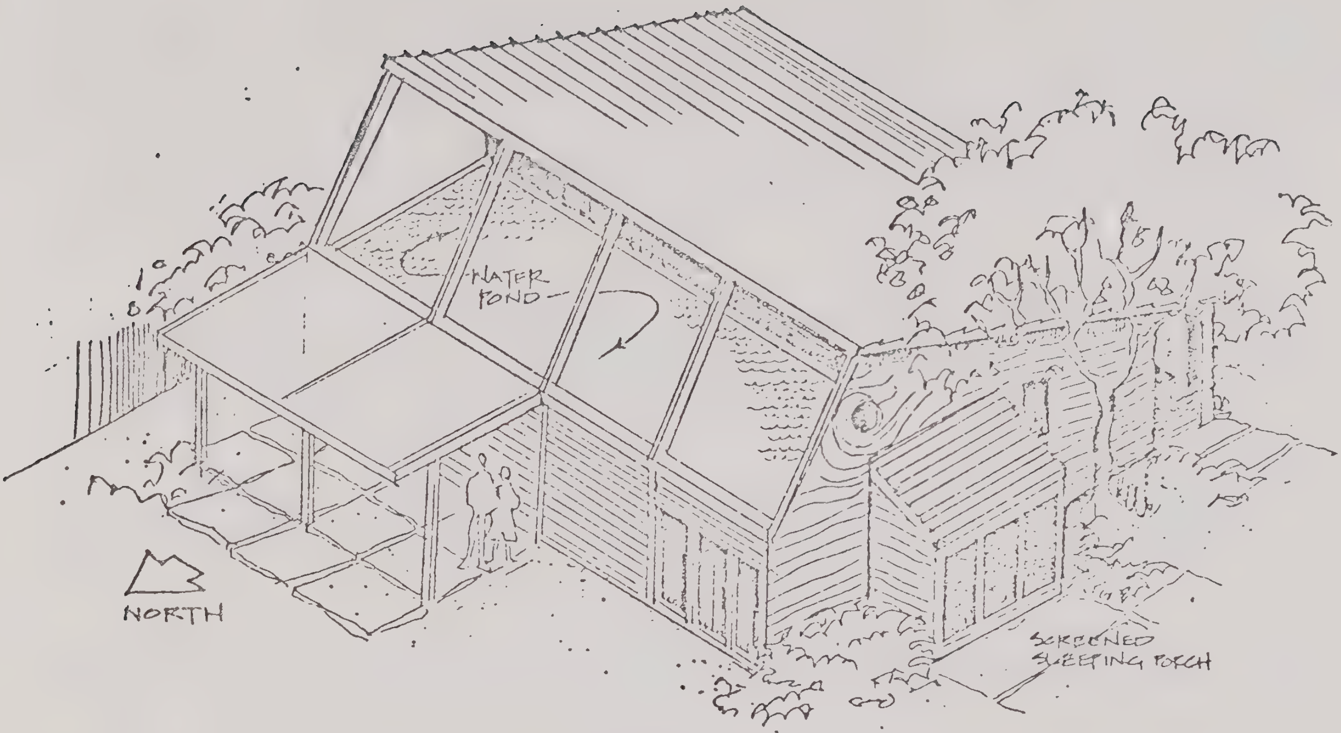
Average Cool Pool Temperature	75 degrees	(Desert comfort range 75-82^{o}F)
Average Air Temperature	91 degrees	
Average High Air Temperature	102 degrees	
Average Low Air Temperature	77 degrees	

Differential between average cool pool temperature and average air temperature: 16 degrees.

Differential between average cool pool temperature and average high air temperature: 27 degrees.

Further research should be conducted to more fully evaluate cool pool performance. The experimental program was conducted by City staff on limited parameter and with a recording device with a history of instability. Ideally, the experiment would include: cloudiness, wind speed, radiant exchange, and an instrument cross check. However, on the basis of the work here, it is safe to say that a cool pool house could be built and that it would work very well, providing all or almost all of the cooling needs of a house in Indio.

The drawing below is a preliminary sketch of how a cool pool house might look. In the winter the water would be drained and insulation placed in the tank. The low heating demand could be met by use of passive solar heating with little difficulty.



COOL POOL HOUSE

Cooling Mode Operation

Water Pond flooded at start of cooling season and insulating panels inside the house are removed. Design of structure is such as no direct sun hits the water. Radiant loss to cool northsky and evaporative cooling occur throughout the day keeping the water at 80°F or less.

APPENDIX C

THE EFFECT OF ROOF MATERIAL ON SOLAR HEAT GAIN

Research data on temperatures below different roof materials are used to project the effect different roof materials would have on interior temperatures. These below roof temperatures are assumed to have a direct effect on interior temperatures and also on energy use for air conditioning. The tests were conducted to refine the performance calculations established in the Energy Conservation Building Code. They should be of interest to anyone building in a hot climate.

The tests were conducted on a series of identical roof boxes at the Living Systems office, near Winters, California. Roof boxes were insulated boxes six inches deep facing south and perpendicular to the noon sun. Data was taken on clear, calm, warm, dry fall days.

Studies were conducted on four pairs of roofing materials, each painted black and white with the same paint. Roofing materials tested included: galvanized iron, cedar shakes, asphalt shingles, concrete tile, and built up tar roofs.

Two different series of experiments were conducted. In the first test the boxes were sealed. In the second series, the entrance hole at the top of the box was unplugged and some ventilation of the roof occurred.

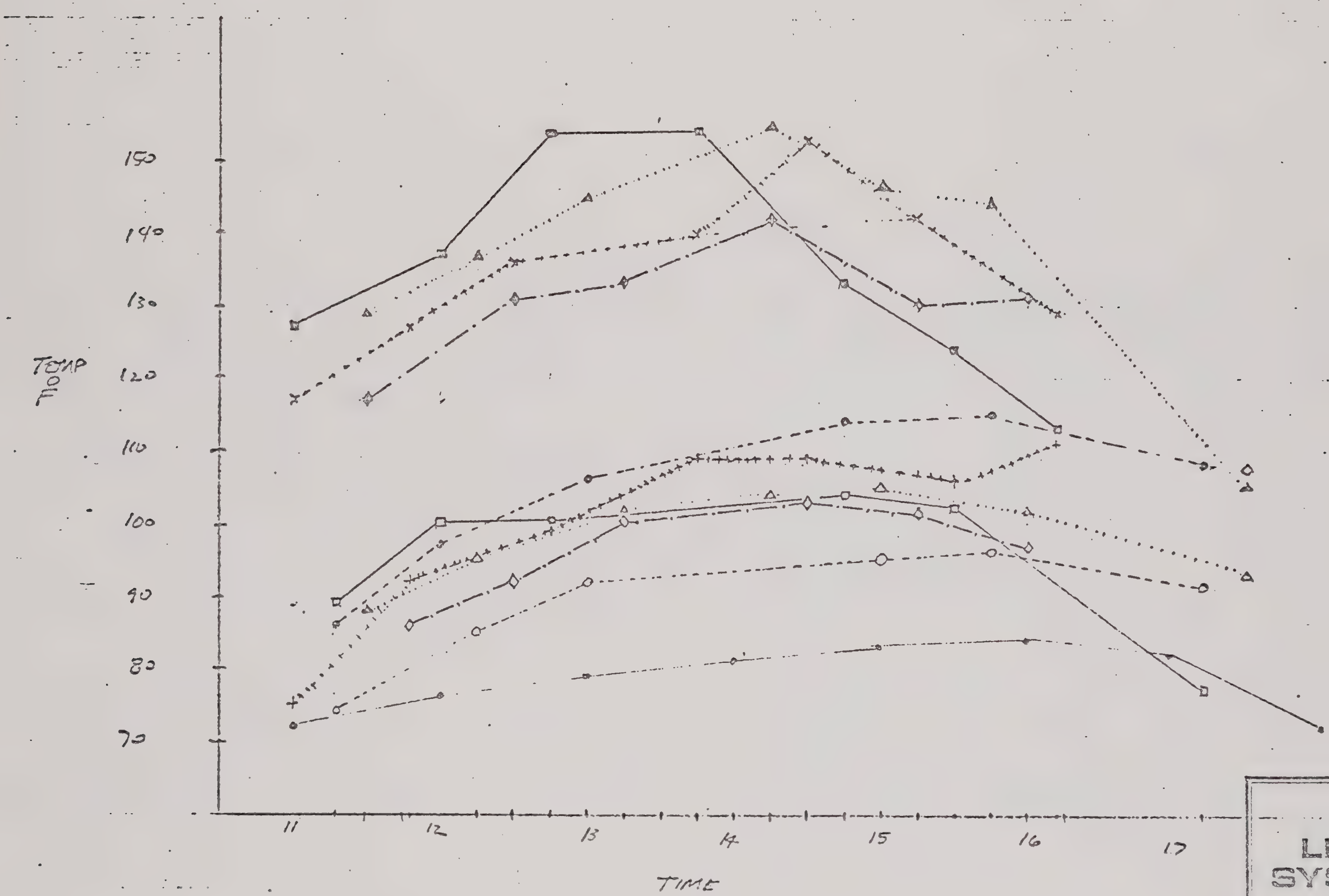
The differences in roof box temperatures were as large as expected and will lead to minor changes in the Energy Conservation Building Code which now considers only color, based on work by Neubauer, Cramer, and Givoni and the standard ASHRAE methods.

The black shakes performed better than expected. The box under the black shakes reached temperatures only slightly higher than the white roofs. The concrete tile also was better than the other roofs although the temperature reductions were not as large.

Typical daytime temperatures are shown below for the vented and unvented conditions.

UNVENTED ROOF EXPERIMENT
OCT 27, 1976

□ 2 w.m.
⊙ 3 black shake
○ 4 w.s.
▲ 5 black tar
△ 6 w tar
8 ◇ umr tile
9 X black as. shingle
10 + white as. shingle
• amb. temp



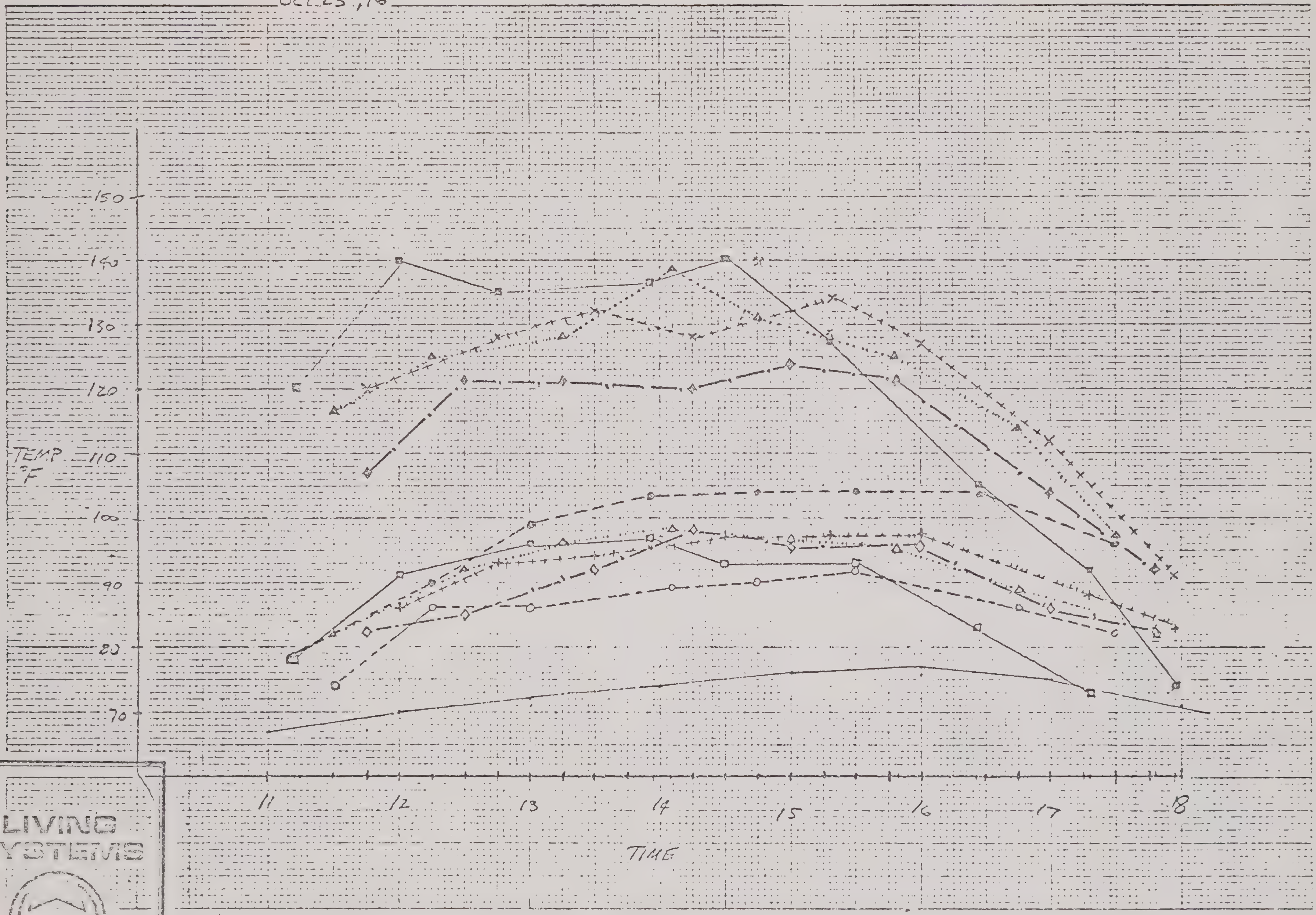
LIVING SYSTEMS

CHAMPION LINE NO. 820-3

CROSS SECTION - 20 SQUARES TO INCH

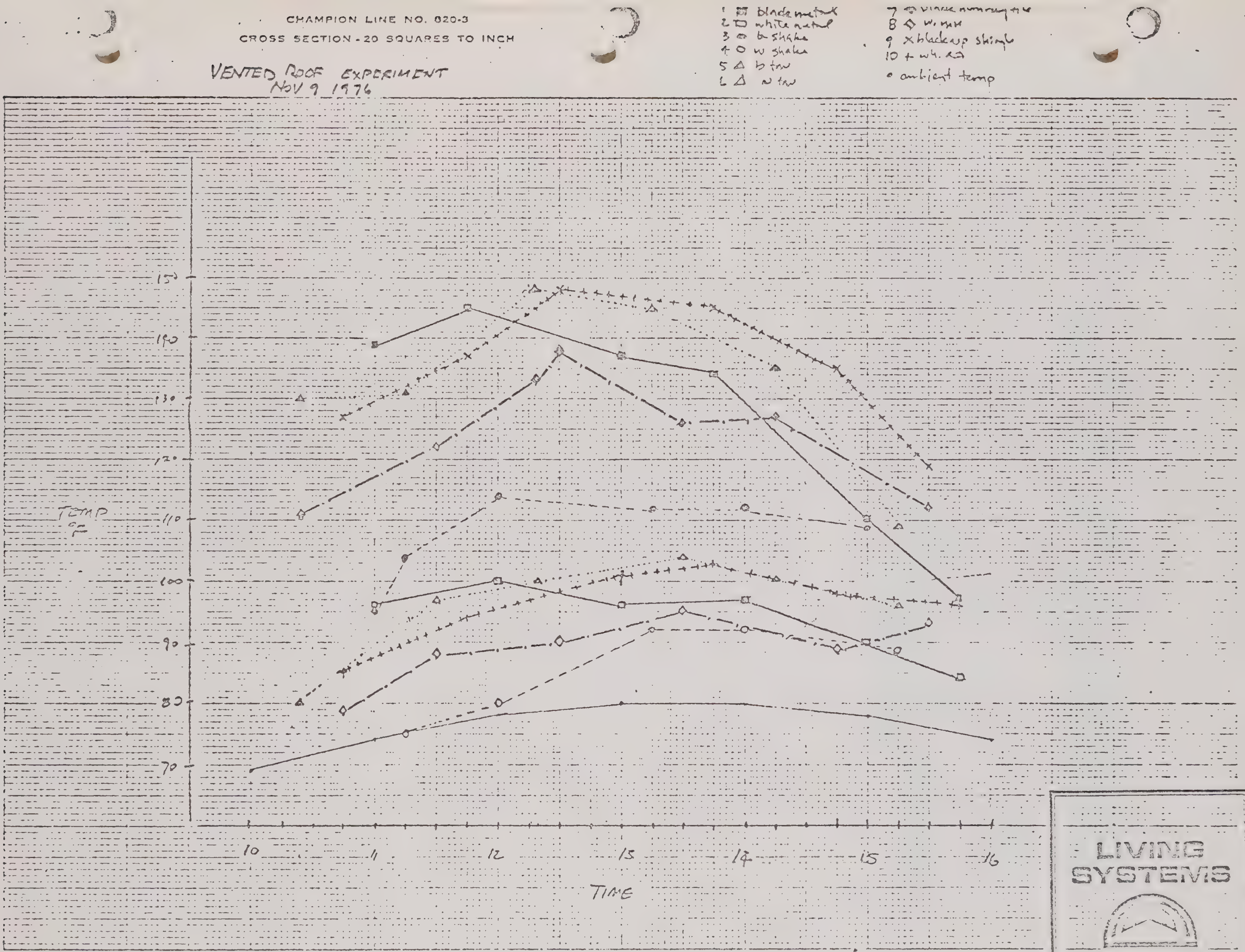
UNVENTED ROOF EXPERIMENT
Oct 25, 76

1 ▣ b metal
2 □ w "
3 ⊙ b shake
4 ○ w "
5 ▲ b tar
6 △ w "
8 ◇ w "
9 × b asp shingle
10 + w "
· ambient temp



93

VENTED ROOF EXPERIMENT
NOV 9 1976



This data supports the previous research and the provisions used in the Energy Conservation Building Code. However, it also suggests that credit should be given for materials which perform better than typical roofing. The calculation of these advantages must include both the effects of roofing material attributable to heat transfer and venting.

The shakes perform well enough to receive credit in TETD calculations. The simplest method is to include the dark shake in the light roof category.

The concrete tile and possibly the shake roofs also ventilate better and deserve additional credit. The standard ASHRAE calculations of roof credit would increase roof resistance by 2 for a ventilated roof. This seems appropriate for both materials when they are installed on open sheathing.

APPENDIX D

SOLAR ENERGY UTILIZATION FOR INDIO AND THE COACHELLA VALLEY

The low desert climate of Indio and the surrounding area offers its inhabitants excellent opportunities for solar energy utilization. The sun is nearly always available providing a dependable source of energy. December and January are the cloudiest months; but, even then, the sun is out 80% of the time possible.

Whether we intentionally try to utilize the sun or not, it is working everyday. The year around warm weather caused by the high levels of solar heating keeps the ground warm. Water supplied to a residence in Indio comes out of the ground at 72° to 74°F into a large holding reservoir from which it moves into the supply grid. The warm ground keeps the water warm so that every Indio resident enjoys 20 to 25% solar pre-heating when compared to residents of cooler climates where the tap water temperature is 60°F or lower. Also, every south facing window into which winter sun is admitted is a "solar collector" helping to keep natural gas usage down. Finally, the warm climate helps keep pools more naturally warm, thereby reducing energy use for pools or even making it unnecessary.

Most people hear the word "solar" and think of flat plate collectors on roofs which heat water or air. But "solar" can also mean cooling by a variety of means if we accept a broader definition of the term. Solar energy is one part of an area's climate and provides a natural source of renewable or renewing energy. Wind is another source of energy which is renewing and is, in fact, caused by the sun. Wind is blowing to transfer heat around the earth in an unending effort to make all spots the same temperature. The water cycle is another complex response to solar energy from evapotranspiration to rain. And, finally, the absence of the sun at night and during the day in the clear north sky is a constantly recurring cooling source. Because these many climate features are all renewable natural resources, the concept of natural heating and cooling is used to more generally describe the situation.

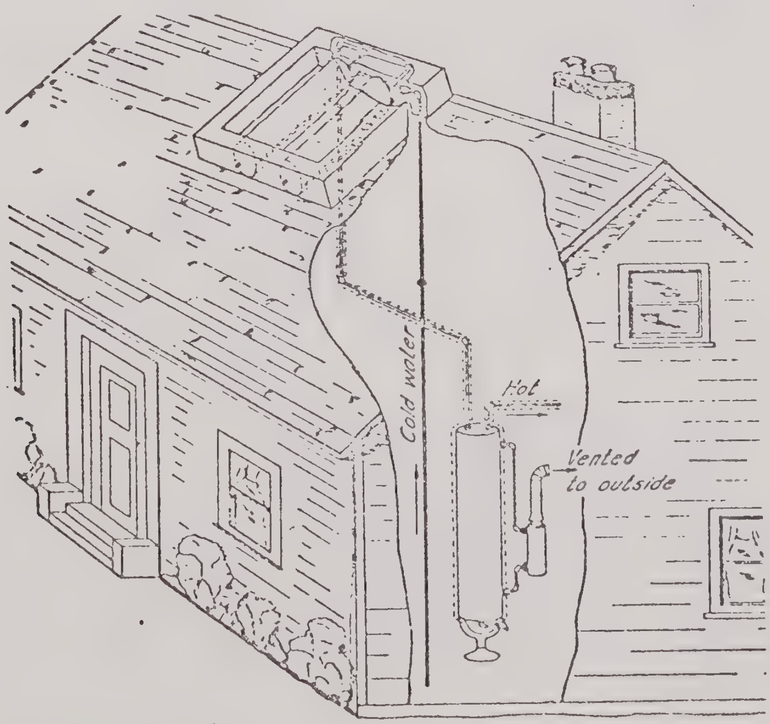
Natural cooling is needed more than natural heating in the Indio area. Cooling by natural means must first begin with making the structure as adaptable to the climate as possible. This means good orientation, better than average insulation, light exterior colors, shaded windows, and, finally, microclimate modifying landscaping to provide oasis coolness with a low level of maintenance and water.

One method of natural cooling which has received a lot of attention and research money is hot water absorption cycle air conditioning. In this system, 200°F water is created by the sun with high efficiency solar collectors and stored in a large tank. A gas air conditioner is modified to operate on the "cooler" solar heated water and circulates the stored hot water as needed. The efficiency of this system is limited by efficiency of the collectors. The efficiency of the collectors is limited by available technology but mostly by money. Large arrays of collectors are required to drive a 4-ton air conditioner even if they are of the very expensive concentrating type. Also, the necessary modification of the gas air-conditioner cuts its rated output significantly. The result of all of these factors is that the costs on the total installation are exceedingly high. Further research and development hopes to lower the overall system costs. This approach is probably best applied to office buildings whose cooling needs extend to almost year-round and to refitting existing houses where major remodeling is not possible.

Fortunately, one does not have to wait for further developments. Viable technologies exist now which can provide nearly all the space heating, space cooling, domestic hot water, and pool heating needed in Indio. The judgment as to the value of each of the various systems or consideration of systems is complex and, in the final analysis, personal. Ways of "objectively" judging the economics of a proposal have been developed, but all have the requirement of making assumptions which are necessarily best judgments as to future unknowns. In the material to follow, general economic data will be given where possible; but actual situations will vary widely and must be individually analyzed.

For those people who are heating their pools, solar heating offers an immediate opportunity to conserve a substantial quantity of natural gas and save money. Few people realize that the difference in initial cost between a solar heated pool and a gas heated pool is small, on the order of a hundred dollars or so more for solar heat. The use of a pool cover can make this bright picture even better by reducing the collector area needed by cutting a pool's heat by 1/3 to 1/2. Many pool suppliers are distributors for one of the several low cost collectors which are well suited to the job. The County of Los Angeles has recently completed extensive testing of various pool heating systems with good results. The best and the cheapest were those made by Fabco, Inc., of Menlo, California. Prices vary widely, but the payback period of most solar pool heating installations is from one to five years. This makes a solar pool heater one of the best solar investments around.

In the late 1920's and into the 30's, California had a viable solar water heating industry of modest proportions. Research done at the University of California's Davis campus produced practical results that were not much improved until the revival of solar work during the 1950's. The simple bulk storage type domestic hot water heater, commonly called the "breadbox", was extensively tested with good results. As shown below, this type of heater is inherently simple

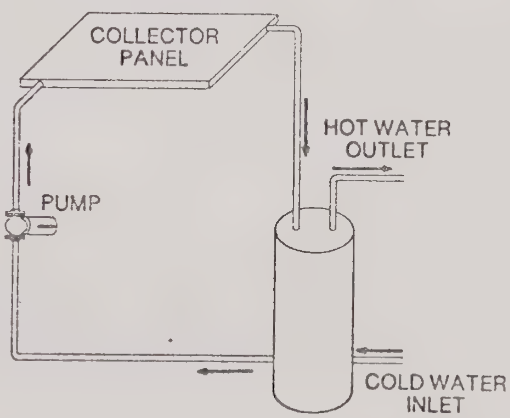


From: F. A. Books *Solar Energy and Its Use For Heating*, *page 36.*

In the Indio area this type heats 90 gallons of hot water (130°F) at the end of the day for 6 to 9 months of the year and good preheating for a standard hot water heater the rest of the year. This type of heater has the inherent advantage of being non-freezing in Indio, easy to construct, easy to adapt for existing structures, and easy to modify to improve performance. The problem with this collector is that it delivers hot water best in the early evening hours if plumbed as shown above. The overall performance is about 75% as good as a standard flat plate collector, but the costs can be kept low. Simple things which can be done to improve its performance are the covering of the breadbox's glass cover with an insulating blanket at night and/or adding a flexible, clear fiberglass covering to the center tube, and/or adding reflectors to scoop up more of the sun's energy. The tanks used in this design were recently purchased at $45 each. Other costs will vary depending on construction detail, but the cost should stay below $1000 and go as low as one's ingenuity allows. This cost range makes it possible to compete with natural gas.

The workhorse of the solar hot water heating world is the flat plate collector coupled to a storage tank. Freezing would not be a problem in most applications in the Indio area, but care must be taken if the particular installation requires an exposed on all sides collector in a "cold pocket" location. A standard sort of setup for a family of four would be a collector of 30 to 50 square feet in size with a storage tank whose capacity is one to two gallons per square foot of collector. The hot water created in the collector is moved to the top storage tank and replaced by cool water from the bottom of the storage tank. This can occur by either natural pumping called thermosiphon or by pumping with a very small electric pump controlled by a special thermostat. Thermosiphon requires that all water lines between the storage tank and the collector be of constant slope and that the bottom of the storage tank be at least one, but best if two, feet above the top of the collectors.

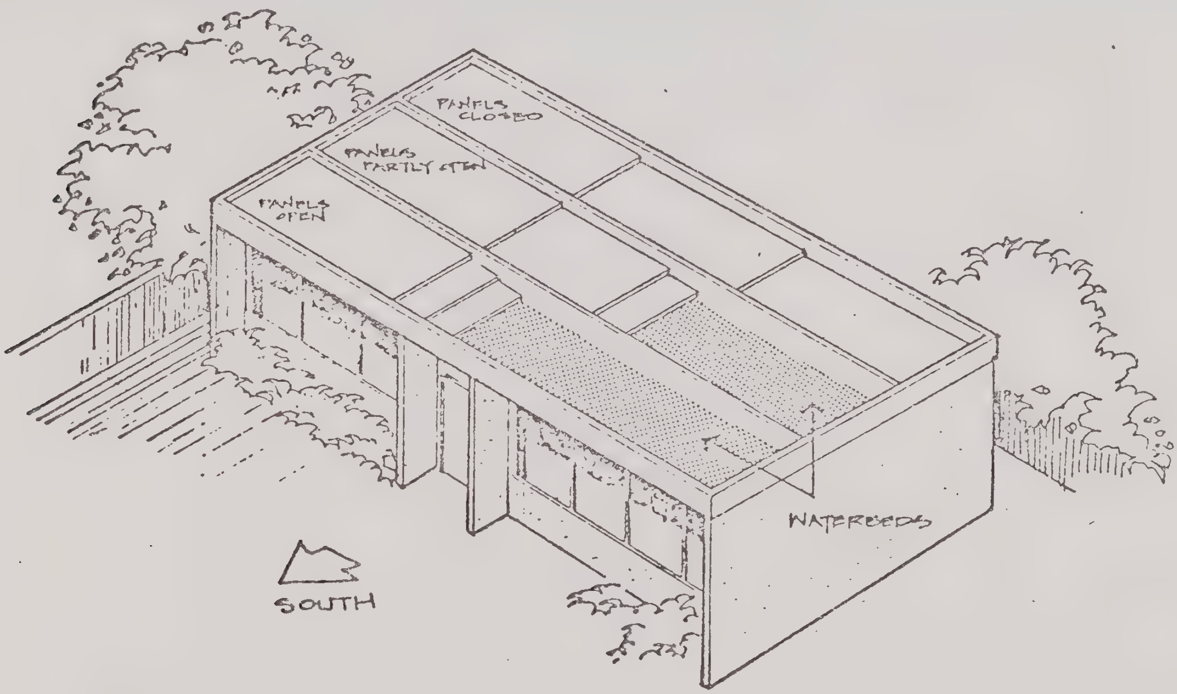
The cost of this type of installation can be from $1000 to over $2500, depending on the size of the system. It competes well against electric hot water with its high costs, but natural gas will have to increase significantly to make the short term economics generally attractive.



The wide range of possible cost of a "standard" system illustrates an important point. How hot the water produced by any system at any certain time is not as important as how many BTU's over a year are put into the water that otherwise would have to be supplied by natural gas or electricity. The weakest link on a system with natural gas back-up is the water left in the natural gas heater. The system should either operate totally on solar or with the solar as a pre-heater with a 30 gallon heater rather than a 50 gallon one. In an electric hot water system, this problem does not exist because the solar storage tank is an oversized, electric hot water heater with the top heating element left on and the bottom heating turned off. But, at today's prices, a solar system with electric back-up would have to be 75% dependent on solar energy just to cost the

same per average month as natural gas alone. Careful design will result in substandard savings in the system costs; but, as the industry standardizes, a standard system will be the least expensive. There are a large variety of collectors available. A standard testing procedure is being evolved so that judgments can be made as to which type of collector is best for the job.

Natural heating and cooling technologies are well suited. A time tested system is available from Skytherm Inc. of Los Angeles, whose head, Harrold Hay, has for many years been a world leader in solar research design and development. His house design has been well tested and would be well suited to the Indio climate. A test house in Atascadero, California, never even got close to its limit. This system, as illustrated below, could be easily adapted to a subdivision building style in Indio which would allow the saving possible through volume to be realized.



SKYTHERM HAY HOUSE

Cooling Mode Operation
Panels opened at night to allow radiant loss from the waterbeds. During extremely hot months the tops of the waterbeds are covered with layer of water to add evaporative cooling. Panels closed during the day.

Research by Dr. Loren Neubauer of the University of California, Davis, on livestock shading devices proved the effectiveness of the north sky's cold spot is providing natural cooling. A prototypical experiment was run in Indio and is reported elsewhere in this report. This natural cooling system has promise for achieving a desired cost level, but needs to be tested in a full sized house. This approach has the advantage of no moving parts on a daily basis. In the spring, the roof ponds must be flooded and the interior insulating panels in the ceiling removed. In the fall the insulating

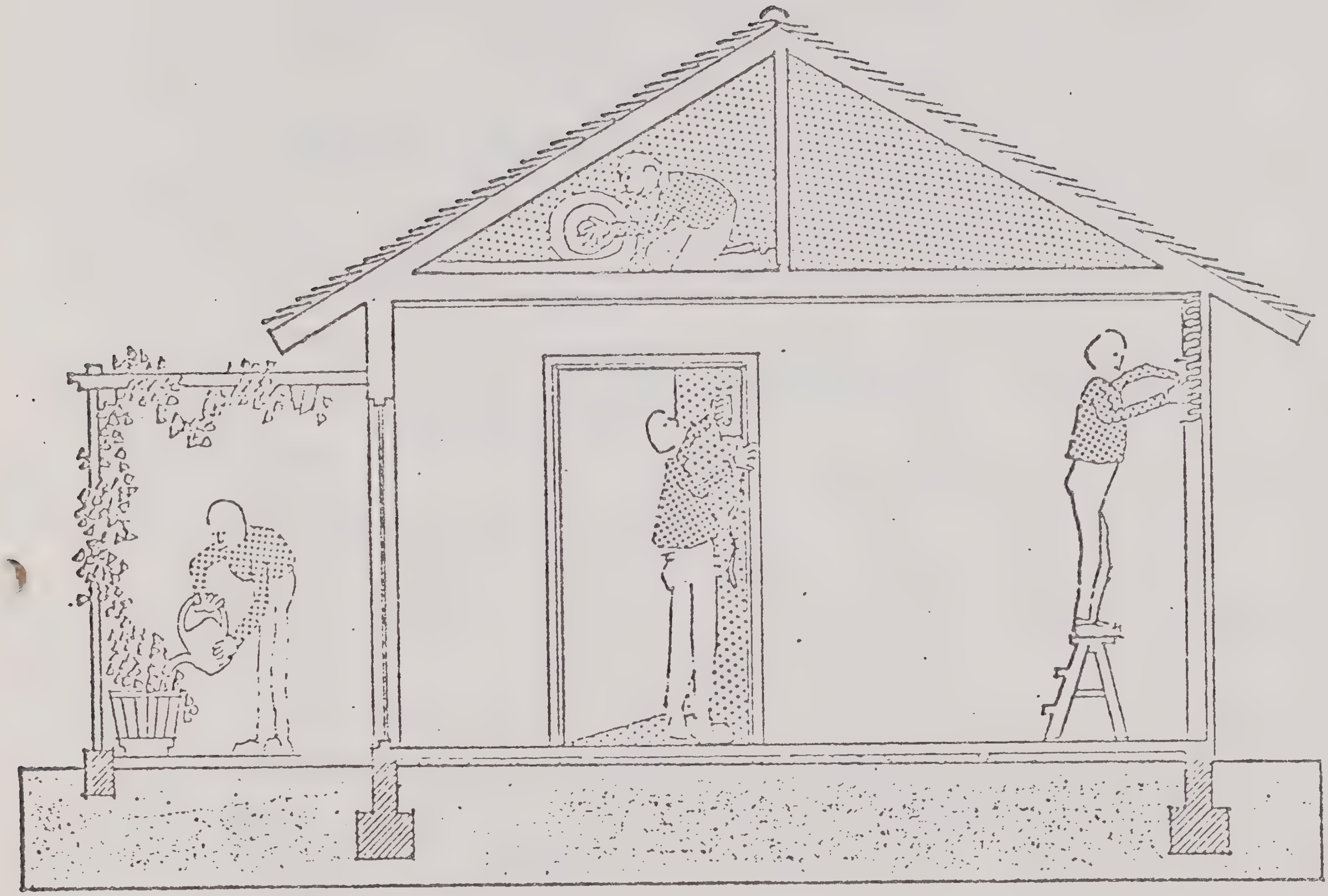
panels are replaced and the pond drained. Experience in designing lower cost, passive solar heating in Davis shows costs equivalent to standard construction plus one to three dollars a square foot can be expected.

One other sure-fire method for natural cooling is building a house which is nearly underground. This is accomplished by either sinking the house totally into a basement, or by building earthen berms against the house. The expense and custom nature of this approach keeps it from having the potential of the other systems. The principle is that the earth can act as an infinite heat sink and source yielding a pleasant temperature of 75 to 80°F.

While the above systems are best suited to new houses, major remodels can incorporate them. Further demonstration and research should actively go forth to bring solar energy use into its own in the desert. A good aspect of presently available solar ideas is that they are often good projects for the do-it-yourselfer.

APPENDIX E

INDIO RETROFIT MANUAL



PREPARED FOR THE CITY OF INDIO,
CALIFORNIA, DECEMBER 1, 1976

Living Systems
Route 1, Box 170
Winters, California 95694
916/753-3033

TABLE OF CONTENTS

HOW TO SAVE ENERGY IN EXISTING RESIDENTIAL HOUSES

The best way to save energy in a house in the winter is to turn down the thermostat, add insulation, and weatherstrip the cracks. In the summer, electricity may be saved for cooling by completing the remodeling for winter savings and adding shading devices or landscaping to protect the east, west, and south windows from direct sunlight. The steps you take to button-up your house for the winter and summer should depend upon the costs and the potential savings in your utility bills. This report provides you with information on the potential cost and benefits of insulation, weatherstripping, and shading devices. It also shows you how to do the work yourself to save installation costs.

In the future, use of air conditioning may have to be cut back because of the prohibitively high costs of electricity. It is important to remodel now so that the home may withstand peak load periods with a minimum amount of mechanical cooling.

I. GENERAL PRINCIPLES

I.A. HEAT LOSS AND HEAT GAIN IN THE HOUSE. The cost of gas for heating and electricity for cooling depends upon the heat loss of the house during the winter and the heat gain during the summer. The sources of heat loss and heat gain are very specific to an individual house. For example, in a house with many small children, the opening and closing of doors to go out and play can be a major source of heat gain and heat loss.

There are three major ways that heat gains and losses occur through the walls and windows of a house: 1) Infiltration, 2) Conduction, and 3) Radiant gains.

I.B. INFILTRATION - WEATHERSTRIPPING. There are two ways cold air moves from the outside and infiltrates a house. The first is the wind blowing the air through the cracks, and the second is the natural tendency for more dense air to replace less dense air. The colder air on the outside of the house is more dense, so it flows through the cracks into the house as warmer, lighter air escapes.

Cold air infiltrates through the walls as well; however, there is little the homeowner can do to prevent the flow of air through the walls. In an average house, infiltration causes 1 1/2 to 2 air changes per hour. This may be reduced to 1 change per hour with proper weatherstripping. This will mean a substantial reduction in heating bills.

Weatherstripping is the most economical means of buttoning up a house and should be the first step in any thermal improvement program for a house.

I.C. CONDUCTION - INSULATION. Conduction is the heat flow between two bodies or from one region of a body to another region of the same body - the force causing the flow is the temperature difference. Heat is conducted through the walls and windows of a house. In the winter there is heat flow from the warmer house to the colder outdoors (heat loss) and in the summer there is heat flow from the warmer outdoors to the cooler interior (heat gain).

Resistance is the property of a material which opposes the passage of heat (energy) through the material. If a homogenous body is at a higher temperature on one side than it is on the other side, then the amount of heat energy passing from the higher to the lower side is determined by the resistance of the body to heat flow. The higher the resistance the better the insulating properties of the material. Glass has a very low resistance value while walls are made of materials with higher resistance properties.

Insulation materials are generally made from glass fiber, mineral wool, cellulose, or plastic foam, and are selected for their high resistance. Insulation is typically rated according to resistance per inch, where "R" is considered the composite resistance for the number of inches used. "R" is simply a reciprocal of conduction which is generally expressed in British thermal units (BTU) per hour.

It is generally best to choose insulating materials with the highest "R" values. Windows as well as walls may be insulated. In the case of windows, interior shutter systems and thermal drapes may be used to provide insulation.

I.D. RADIANT GAINS - SHADING. Radiant heat is energy transmitted by electro-magnetic waves. The infrared wavelengths are the primary source of heat. In both the summer and winter, sunlight penetrating windows of a house causes radiant heat gain. In the winter the radiant heat gain is welcome because it heats up the house and reduces the need for gas or electric heating. In the case of solar tempered houses which have a substantial amount of south facing glass and back-up thermal storage capacity, such as an exposed slab or water in tubes, it is possible to use the sun for almost all of the heating needs of the house.

The summer radiant heat gain is not a benefit, but rather a detriment for it increases the air conditioning load. The best strategy for preventing the summer radiant heat gain is to shade the windows. Shading may be achieved with trees or landscaping or through use of shading devices such as awnings, kool shades, or bamboo shades. It also helps to shade exterior walls and the roof if it is possible.

II. THE ECONOMICS OF REMODELING A HOUSE WITH INSULATION AND WEATHERSTRIPPING

Before investing in insulation and weatherstripping, you should work out the capital costs versus the energy costs so that you will receive the greatest benefit for your dollars. It makes good economic sense to invest in insulation. One Federal study has pointed out that you can earn greater dividends by investing in energy conservation improvements in your house than by putting money

in the bank. The dividends accrue in the form of reduced utility bills. These dividends pay off the investment, pay "interest", and increase the value of the house for resale. And unlike dividends from many other investments, the returns are not subject to income tax.

When investing in weatherstripping, insulation, and shading to screen out the summer sun, you should consider that you save both natural gas for heating in the winter, and electricity for cooling in the summer. The following information should help you figure out the economics of weatherstripping and insulation. (Figures for a 1400 square foot Indio tract home with R-7 insulation in the attic.)

CASE 1

We have an air conditioning system. Will it pay to insulate, weatherstrip, and add shading devices?

Investment Cost ft/sq.		Tax Free Return on Investment	Savings per Season
Weatherstripping	$ .15 - .40	93.00% - 247.00%	$ .37 linear ft.
Shading Windows	$1.50 - 5.00	13.73% - 109.8%	$ .55 square foot
Insulating Attics	$ .25	32.8%	$ .08 square foot
Insulating Walls	$ .50 - .60	14.00% - 11.67%	$ .07 square foot
Insulating Floors			

CASE 2

Or alternatively, I don't own a central air unit; should I buy one or invest in insulation, weatherstripping, and a small air conditioner?

A. $2500 for 3.0 tons of air conditioning.

B. $1215 for insulation, weatherstripping, and shading, plus $300 for small air conditioning unit; for a total of $1515 (about a $1000 initial savings)

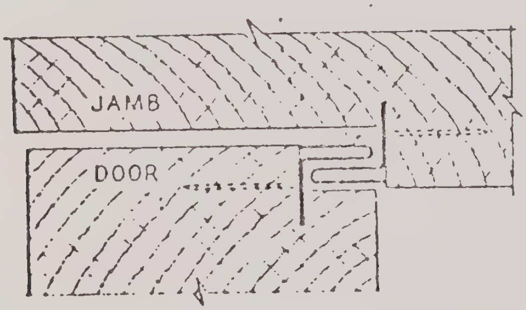
Air conditioning bills for an entire season are very much dependent upon the efficiency of the unit. In the case of our sample 1400 square foot typical Indio house, 5.8 tons are required to meet the peak load cooling needs. The seasonal costs are listed below depending upon efficiency of the unit.

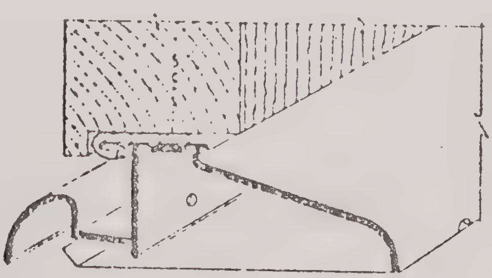
Efficiency of the Unit	Energy Use per Ton	Full Load Hours	Energy Use per Season per Ton	Energy Cost per Season
EER 4	3.00 KW	1452	4356	$119.79
EER 6	2.00 KW	1452	2904	79.86
EER 8	1.50 KW	1452	2178	59.90
EER 10	1.20 KW	1452	1742	47.92

III. WEATHERSTRIPPING

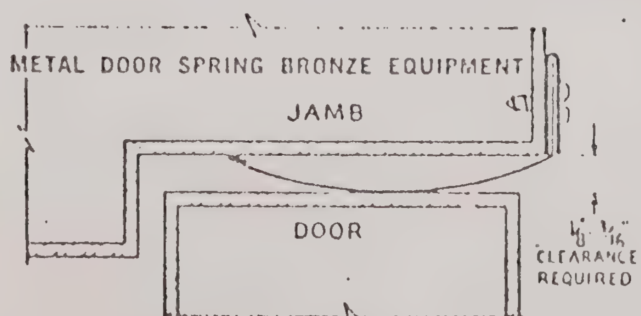
Before installing weatherstripping, it is important to discover which windows and doors need it. Wait for a windy day, and then go around the house and feel where the wind is leaking in. Frequently, it will be underneath the doors or around sliding glass doors. Each type of crack should be handled with a different weatherstripping treatment. Weatherstripping is comparatively inexpensive and easy to install. In many cases an entire house can be weatherstripped for less than $75. After weatherstripping, the next most cost effective means of improving the energy efficiency of a home is to add insulation.

III.A. DOOR PERIMETERS OR JAMB. There are three types of weatherstripping for the perimeter of doors: interlocking, steel spring, and gasket. The interlocking weatherstripping is the most effective, but also the most expensive to install. Interlocking weatherstripping must be routed into the door. The following drawing provides a perspective of how interlocking weatherstripping works.



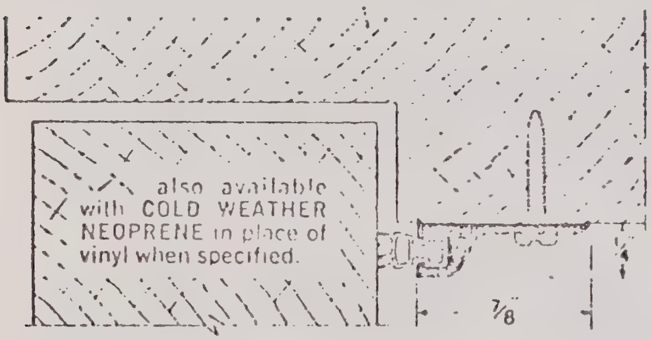


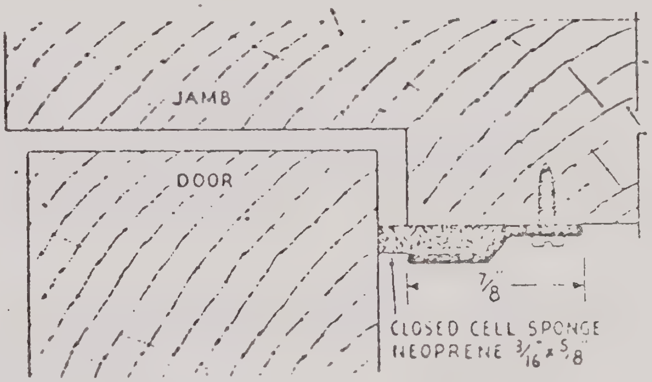
Spring weatherstrips are made of bronze, aluminum, or stainless steel. The aluminum strips are cheaper, but they are weaker and may break. Spring weatherstripping consists of a ribbon of spring metal that is usually as wide as the door permits. It is mounted on the jamb with nails or metal screws in a position where a door will close against it. One edge is usually made with a slight crimp; so when this edge is fastened to the jamb, the other portion of the strip is thrown out so the door closes against it with a slight pressure.



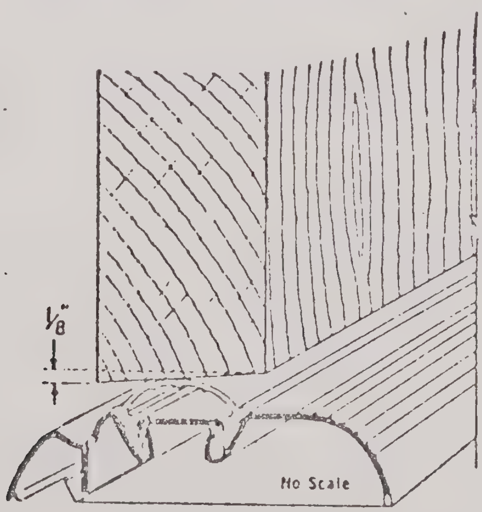
The gasket weatherstripping consists of an aluminum strip which holds a vinyl, rubber, or neoprene extrusion, or a sponge rubber or felt strip, or plain felt, or wool pile. The development of vinyl and neoprene strips made gasket weatherstripping an economical and effective method. Neoprene and vinyl do not wear out like rubber or felt or wool pile. Unlike spring weather-stripping, it is almost impossible to damage gasket weatherstrip to the extent that it becomes ineffective, especially when screw holes are slotted for adjustment.

Gasket weatherstripping is nearly always surface applied, which means that it does not have to be routed to be applied. It is quickly and easily installed. Most types have slotted screw holes or other provisions so that they may easily be adjusted to changing conditions, such as the settling of the building or the wearing of the door jambs. The following are different types of gasket weatherstrips.

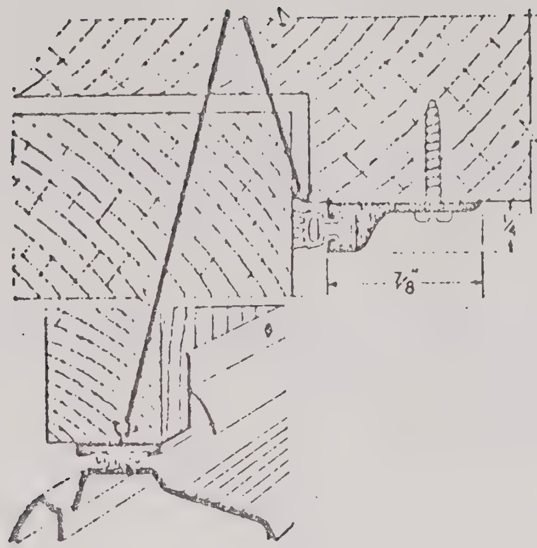




III.B. UNDER THE DOOR AND THRESHOLD WEATHERSTRIPPING. There are two types of systems commonly used for weatherstripping underneath doors. One uses a neoprene rubber strip attached to the threshold as shown in the drawing.



This system has the disadvantage of being rendered ineffective after being constantly stepped on over the years. A much better system is shown below which has the neoprene seal attached to the door. This type of strip is easy to attach and lasts for many years.

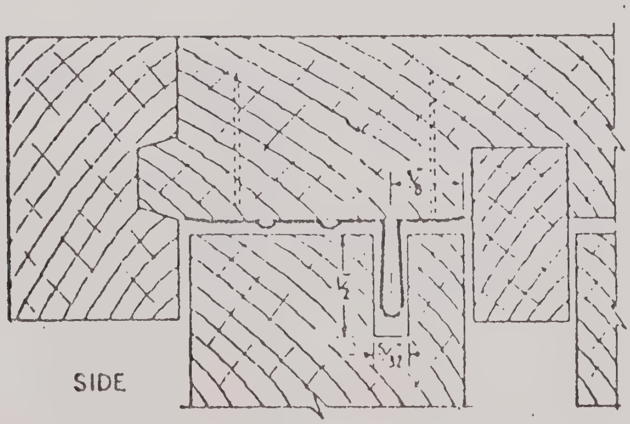


Another type of underdoor weatherstripping is the automatic door bottom which raises when the door is opened and seals on the threshold when the door is closed. The automatic door bottom is difficult to install since the door must be routed out. Generally, the automatic door bottom is only used for special purposes such as hospitals because of its high cost.

Garage doors should be weatherstripped with door sweeps which will keep out water as well as drafts. The advantages of the sweeps are ease of installation and low price. On outswinging doors, the rubber types are quite effective. On inswinging doors, sweeps cannot be used.

III.C. WINDOW WEATHERSTRIPPING. Windows are far more difficult to weatherstrip than doors. Only wood frame windows can be adequately weatherstripped after installation, and this is very costly. As can be seen from the drawing, in order to weatherstrip a wood frame window, the frame must be routed out to create a slot for the metal strip that inserts into the slot. The metal strip is attached to the sash.

Most houses in Indio are constructed with metal windows, and these cannot easily be weatherstripped. In the winter when the windows do not need to be opened, it is best to tape the cracks with a neoprene strip or duct tape to prevent the infiltration of cold air. This cannot be done in the summer when it is necessary to open the windows at night.



IV. INSULATION

IV.A. RESISTANCE OF INSULATION MATERIALS. It is generally best to choose materials with the highest "R" value. The following is a table of resistance values for commonly used insulating materials:

TABLE 1
R VALUE FOR COMMONLY USED INSULATING MATERIALS

	R per inch
Blankets or batts	
(fiber glass or rock wool)	$3.67
Loose Fill	
cellulose (milled paper)	3.50
fiberglass or rock wool	2.17
vermiculite (expanded)	2.13
perlite, (expanded)	2.70
Boards	
expanded polystyrene	5.00
expanded polyurethane	6.26
mineral fiber with resin binder	3.45
Injected foam	
polyurethane	6.15
urea formaldehyde	6.00

IV.B. OTHER PROPERTIES. When choosing insulation for the walls and attic, resistance per inch should not be the only consideration. It is also important to select a material which is not flammable. For several years after polyurethane foam was developed, it was considered a miracle material because of its extraordinary resistance properties, ease of application, water repellent qualities, and light weight. However, several disasters in which many lives were lost revealed its explosive, flammable properties.

Similarly, almost all plastic insulation products suffer the problem of flammability even though manufacturers claim that they have found chemical treatments which have eliminated the problem.

IV.C. FIBERGLASS OR CELLULOSE IN THE ATTIC. When it comes down to the first choice of a product for insulating your attic and walls, the choice will probably be between fiberglass, mineral wool, or cellulose. Cellulose insulation is manufactured from ground-up newsprint which is treated with chemicals for moisture resistance and fire retardant properties. Both materials have their advantages. Fiberglass is a time-tested, insulating material; and when installed in batts or rolls, it is of a standard thickness and will not settle. It is also simple to install batts or rolls. In contrast, the homeowner rents a blowing

machine to insert cellulose insulation or pours it from bags. It is more dusty and messy than fiberglass, but it is not as irritating to the skin. Cellulose products have a higher "R" value per inch than loose fiberglass and are manufactured from a recycled material. For attic insulation, the choise is a matter of consumer preference - cellulose or fiberglass.

IV.D. WHAT INSULATION FOR THE WALLS? If the decision is made to insulate the walls, then the choice is somewhat different. Fiberglass batts cannot be inserted in the walls without removing the sheetrock or the siding. Thus, the choice to the consumer is either blowing in cellulose or another material. Generally, holes are made in the siding of the house and the material is inserted under pressure. Vermiculite, foam, and cellulose have all been used for this purpose. Urea formaldehyde foam and cellulose are the two materials now commonly in use.

Urea formaldehyde foam has an extraordinary high "R" value and has been used successfully to insulate the walls of houses on the East Coast for a number of years. There are some problems with this product, and we have still not received adequate answers to our questions. Therefore, cellulose is recommended for wall insulation. Cellulose has its problems, too. It settles if not installed properly, and some brands may absorb water. If cellulose insulation is installed in the walls, it is most important that a non-water absorbing material be used and that the holes be properly sealed after installation so that the vapor barrier of the house is maintained.

IV.E. BUYING INSULATION. All fiberglass insulation is the same. An R-11 batt is an R-11 batt, whether it is manufactured by Owen-Corning, Certain-Teed, or John Mansville. A batt is the same as a roll except it is more rigid. Batts and rolls come with foil backs or kraft (paper) backs. If the foil back is in a place where it can be kept clean, it will provide a slightly higher "R" value than the kraft backed. In order to assist the consumer in choosing insulation, we have completed a survey of products and prices from the local firms selling insulation.

You should not pay more than 13 cents per square foot for R-11 batts or rolls, and 22 cents per square foot for R-19 batts or rolls.

If you don't want to buy insulation and install it yourself, there are a number of firms that will do the job. Historically, the insulation industry has had more than its share of suede shoe salesman and con artists who have sold consumers poor quality products at exhorbitant prices. This is still a problem today, so it is important to check carefully before retaining a contractor.

Before choosing a contractor, check his reliability with the Better Business Bureau and also ask him for references, including other people who had insulating work completed. Also, look at the bag and see how many square feet will be covered by one bag at the required thickness and make sure the correct number of bags are used. All bags should be labeled as follows:

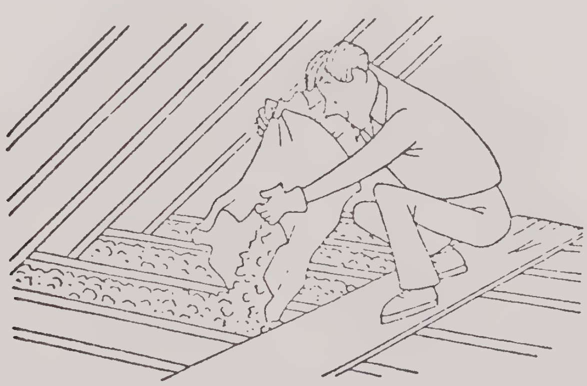
R-22	10"	45 sq. ft.
R-19	8-3/4"	51 sq. ft.
R-11	5"	90 sq. ft.

Most insulating contractors will blow in cellulose or fiberglass insulation into attics, and cellulose or foam into the walls. A contractor can blow your attic with insulation for the same price as you can buy batts and install them yourself. However, if you do the work yourself, you will probably do a slightly better job and will have the feeling of satisfaction of completing an important remodeling job on your house. In addition, fiberglass batts don't settle, while both cellulose and blown fiberglass will settle some, reducing the insulating qualities of the material.

If you choose to have a contractor complete the work, you should not pay more than 22 cents per square foot for insulating the attic and 55 cents per square foot for the walls.

IV.F. HOW TO INSTALL INSULATION YOURSELF.

1. The Attic. Lay down boards to walk and move around. If you step between the joists, you may crack or step through the ceiling. If you are going to use batts or rolls of fiberglass, choose either R-19 or use two layers of R-11. These batts should be laid down between the joists, no stapling is necessary. If you use two layers of R-11, lay one down between the joists and criss-cross another on top of the joist. Fluff up your insulation before using it like you would shake out a tablecloth. Work from the outer edge of the attic toward the center. Hand-pack insulation around pipes and electric cables.

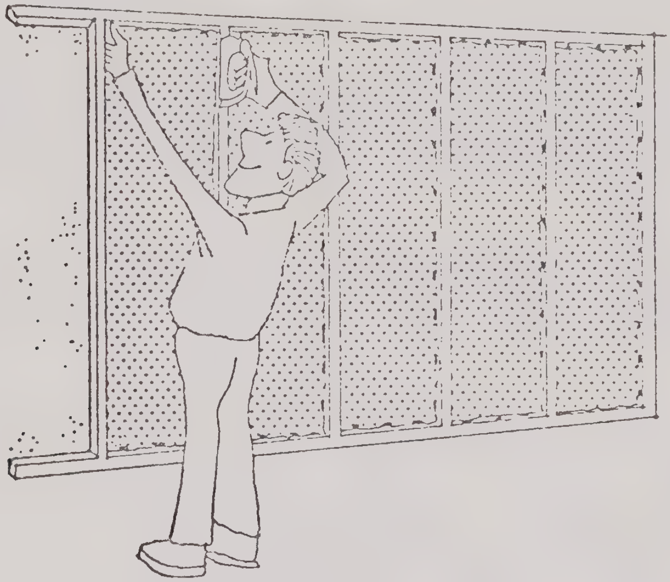


If you use cellulose or other loose fill insulation, pour it to a depth of at least 6 inches and rake it with a hoe until it is of even depth.

When insulating the attic, don't cover recessed light fixtures, meters, and other heat-producing equipment; and don't place insulation on top of vents. If you are using loose fill insulation, it will be necessary to construct a baffle around the vents and heat-producing equipment.

2. The Walls. It is difficult to insulate the walls by yourself. You can take out the sheetrock and put in batts of fiberglass or you can take off the siding and put in batts.

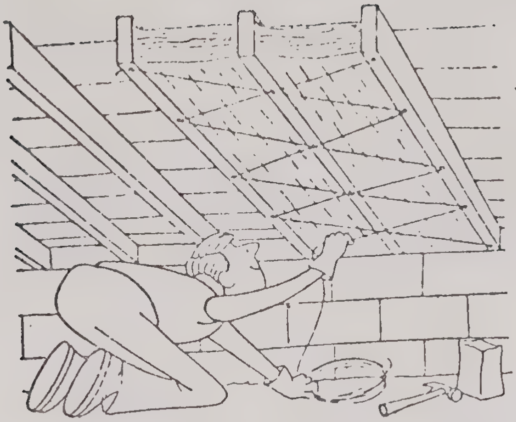
If fiberglass batts are used, the kraft and foil paper barrier should be on the inside and should be stapled to the studs. The following drawing shows the correct method.



A homeowner can blow cellulose into the walls if he or she rents the equipment. A 3/8" or 1/2" drill is needed to make the approximately 3" diameter hole above and below the fire wall, between each pair of studs. Subsequently, the cellulose is blown into the cavity with the blowing machine. After filling each cavity, the holes in the wall must be plugged. A polyurethane plus is recommended with use of a vinyl patch to maintain the vapor seal. Frequently, the house must be repainted to hide the patches.

3. Floor. If your house is equipped with a concrete slab, there is no way to insulate the floor. However, heat loss around the edge of the slab may be prevented. A trench one foot deep may be dug around the perimeter of the slab and polystyrene placed around the edge. We recommend that the surface of the slab be exposed since it serves as a heat sink and stores the warmth of the house during the day, and releases it at night. Parquet doesn't reduce heat transfer much, but carpets do.

Houses with wood floors should be insulated underneath the wood tongue and groove boards. Fiberglass batts are best for insulating the floors. Push the batts or rolls between the floor joists from below, vapor barriers up, and lace wire back and forth among nails spaced about two feet apart pounded into the bottom of the joists to hold in the batts. Pieces of blanket cut to size should be fitted along the sill at the ends of the floor area. See the drawing below.



4. Insulating Ducts. A significant amount of heat may be lost through the heating ducts in the attic or on top of a flat roof. The first step should be checking the joints of the ducts for leaks and taping them with duct tape.

If there is no insulation around the ducts, it is worthwhile to add one inch or two inches of fiberglass. The duct insulation may be bought at insulation companies and is pre-sized for the diameter of the duct. Then simply slide it around the duct and tape it.

IV.G. HOUSES WITHOUT ATTICS. Many houses were built in Indio without insulation, or only a couple of inches, and have no attics. These houses with open beam ceilings present a difficult problem. The easiest solution is to staple in fiberglass batts between the open beams and place sheetrock over the open beams. The cost is about 33 cents per square foot and is the cheapest way to go; however, one of the nicest features of the house is covered.

The other alternative is to lay sheets of polyurethane insulation on the roof, a layer of plywood, and new roof surface. This is costly, but effective. The same result can be achieved by hiring a polyurethane foam rig to spray the material directly on the roof and then covering it with a waterproof white silicon paint. This is a much cheaper process and can be completed for fifty cents per square foot if several houses in a block are done at the same time. One disadvantage of this process is that you cannot walk on the roof without leaving giant foot prints. Nevertheless, this system may be effective with proper installation of the material. Unfortunately, there have been cases in which the material was improperly applied resulting in an extremely costly problem for the homeowner.

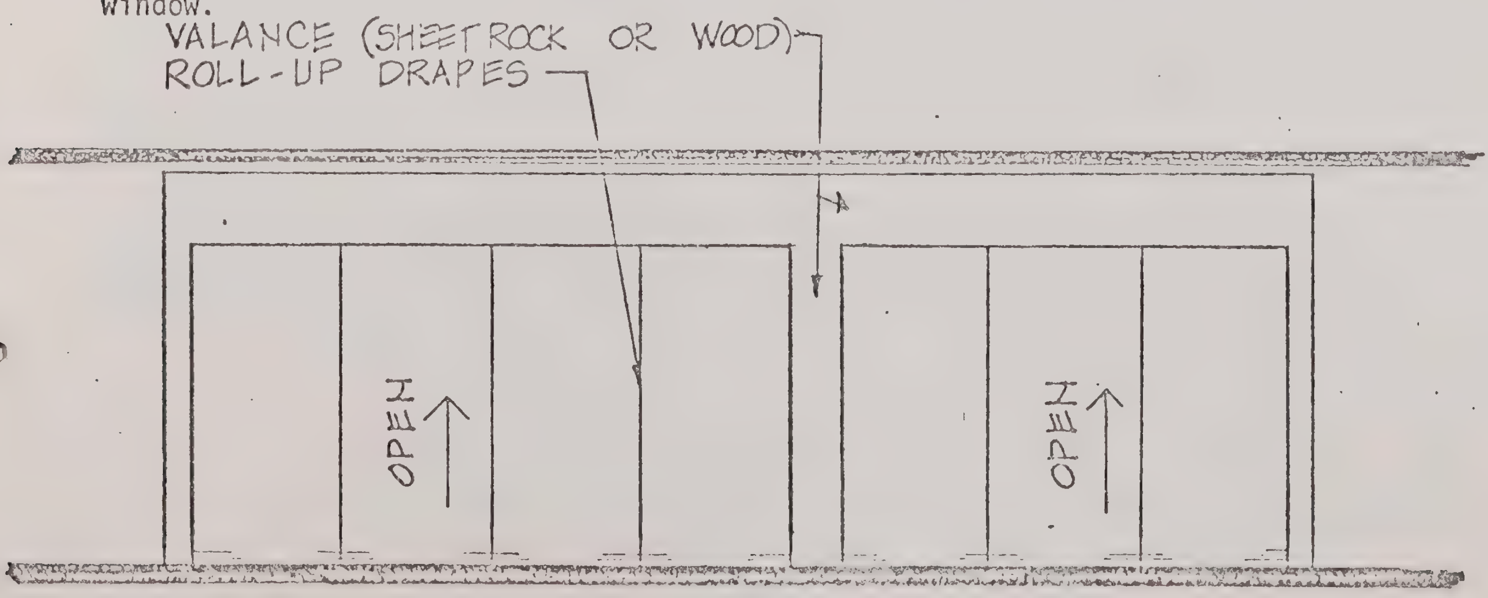
IV.H. WINDOWS. Between 10 and 30 percent of the heat gain and heat loss of a house can occur through the windows, depending upon the area of walls in glazing. There are several myths about the use of drapes for energy conservation, one of which is that the use of drapes will cut the heat loss of a home during the winter. Actually, drapes can increase the heat loss through the windows because they create an inverted heat stack next to the window which accelerates convection currents. However, well sealed drapes that touch the wall and floor do help and can reduce conductive losses. There are methods of cutting down heat loss through windows that are more effective - some are costly and others very expensive.

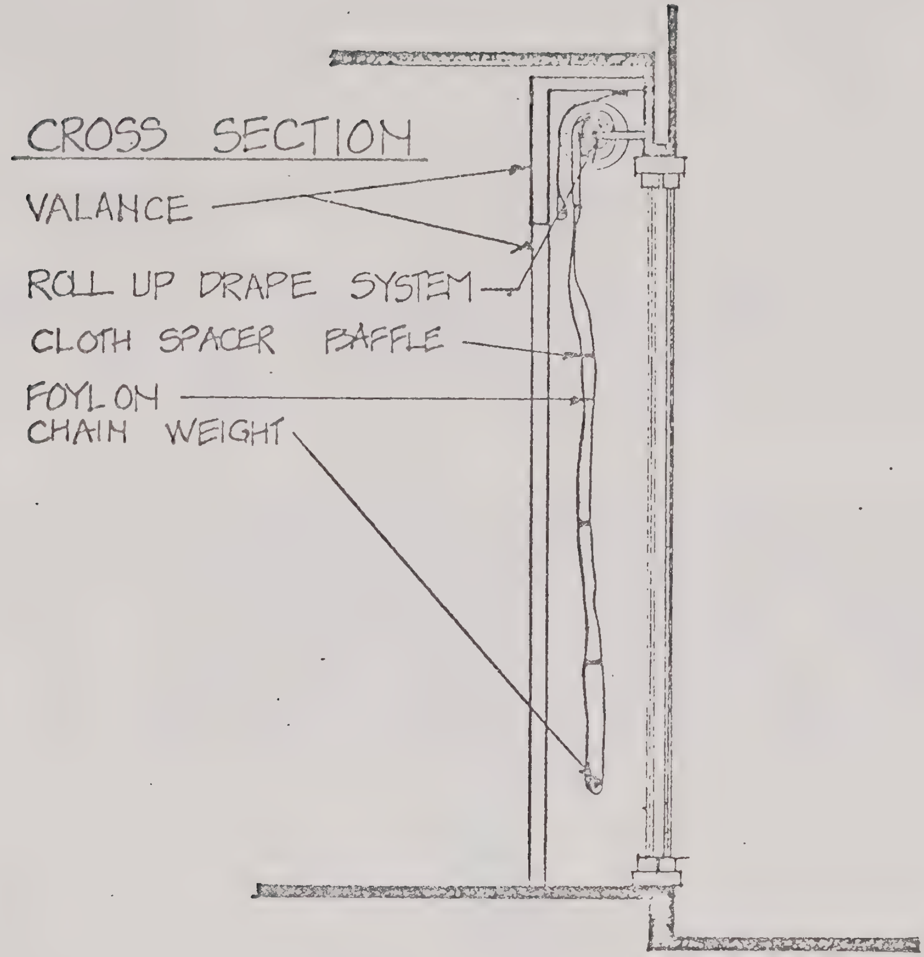
The most expensive and effective system is to build interior shutters which are a sandwich of styrofoam and particle board. An interior shuttering system will cost about $5 per square foot of glazing. Slightly less expensive is thermal pane glass which is $2 to $3 per square foot. The following photo shows a movable insulation system.

Thermal pane glass and shuttering systems are not economically feasible for most houses, so we have put together some ideas for less expensive methods of sealing windows.

The Foylon sealed drapes (Foylon is a product of the Duracote Co.) are very effective in keeping heat in the house in winter and keeping the heat out in the summer. Foylon is a reflective material that has some insulation properties and is relatively inexpensive. The following drawings show thermal drapes made of Foylon.

If drapes are to function as part of the thermal system of the house, they must be sealed tightly to the window. We suggest using a valance on top of the window.





V. SHADING

Many of the same techniques used to button-up a house and keep it warm in the winter are also effective in keeping a house cool in the summer in the hot desert climate. Insulation, weatherstripping, and shuttering of windows all serve to keep the heat out of the house in the summer.

The optimum strategy of natural cooling in the Indio climate is to shut the heat out during the day and ventilate the house at night when the cooler air comes in. In addition to buttoning-up the house for protection, it is also necessary to shade windows in the summer to minimize the radiant heat gain.

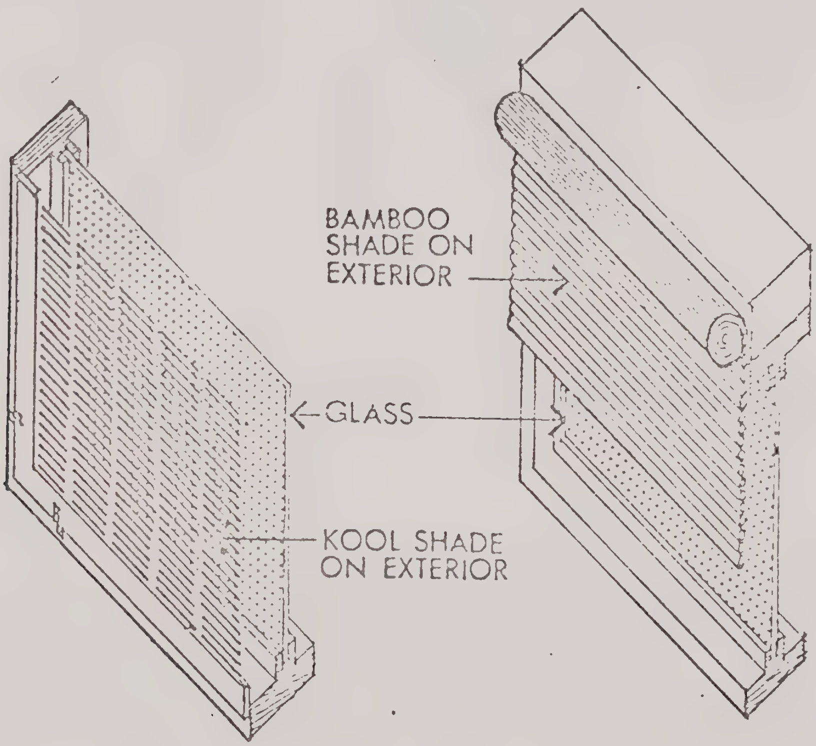
On a peak day in the summer, 12,000 BTU's of heat are gained through a 55 square foot west facing window. This is equivalent to a ton of air conditioning or between 1 and 2 kilowatts depending upon the efficiency of the air conditioning unit. In addition to the operational costs of the air conditioning needed to compensate for the radiant gains, there is also the cost of replacing the unit every 5 to 10 years.

According to our calculations, a typical east-west oriented 1400 square foot typical Indio tract home will use between $300 and $400 dollars for air conditioning in a typical season. This energy usage can be cut in half by shading windows. Typically, a savings of $5 per 10 square feet of glazing is possible by shading windows:

East-West Shade Screen	South Shade Screen
10 square feet for each $4.08	10 square feet for each $3.83

IV.A. SHADING SYSTEM. The most expensive exterior shading system is Kool Shade which is approximately $5 per square foot. Kool Shade is placed in frames much like bug screens and installed only during the hotter months. Kool shade allows the individual to see out, but prevents the sunlight from coming in.

Kool Shade is made out of bronze; however, there are a number of less expensive copies made out of aluminum which cost around $1.50 per square foot. Clearly, this type of shade screen would pay for itself in about three seasons. There are other less expensive alternatives which will pay for themselves in one season. The most widely used of these systems is the bamboo shade screen. One figure below shows a house using Kool Shade to keep the summer sun out, while the other figure shows a house using the old standby - bamboo shade screens. Awnings may also be used to keep out the sun in the summer.



IV.B. COOLING THROUGH LANDSCAPING. More effective than shade screens is the use of vegetation for cooling. Mature, deciduous trees may cool the microclimate of a house by as much as 20°. For the Indio area, good trees are carob, locust, silk, and bottle, and sumac. If the trees are planted on the east-west sides of the house, they will provide shade in the summer and allow the winter sun to penetrate the walls and windows and provide warmth.

On the south side, it is often appropriate to plant an arbor over the south window which will provide shade in the summer but allow the winter sun to penetrate.

DECIDUOUS TREES ON EAST & WEST SIDES

ARBOR WITH DECIDUOUS VINES OVER SOUTH-FACING WINDOWS

VI. AIR CONDITIONING

In the Indio climate some type of mechanical cooling system is necessary to keep the house cool. For many years evaporative coolers, more commonly known as swamp coolers, were used in the Indio area. However, in the late fifties and early sixties, many of the swamp coolers were replaced with air conditioning systems. During that period, air conditioners became cheaper and easily available. As air conditioners became more readily available, somehow it became a widespread belief in the community that the climate had changed and swamp coolers were no longer suitable because of the greater humidity. In reality, weather data indicates that there has been no change in humidity in Indio.

Swamp coolers have never been suitable in areas of high humidity and cannot be used in Indio in locations close to irrigated agriculture or where there is intensive watering of a lawn. However, swamp coolers remain effective in homes which are well designed and have some advantages over air conditioning. The greatest advantage is swamp coolers use a fraction of the amount of electricity that air conditioners use. The other advantages include bringing a large quantity of fresh air into the house, very cheap maintenance costs, and low initial cost.

If swamp coolers are used, windows must be kept open so that the humidity doesn't build up in the house; the water in the cooler must be carefully regulated, and the water pads must be kept clean. Comparative tests between air conditioners and swamp coolers have found a small evaporative cooler, on the average, was about as useful as the air conditioner, being especially effective in the hottest, dry weather.

Granted that most Indio residents have air conditioners and may be in the market to replace their air conditioning system, there are some steps which can be taken to improve the efficiency of the units. The filters should be checked carefully each season and cleaned. If they are worn, they should be replaced. The duct unit should also be checked to make sure that there are no leaks. All leaks should be taped with duct tape. If ducts are uninsulated, they should be insulated with at least one inch fiberglass duct insulation.

The microclimate of the area where the air conditioning unit is placed is extremely important. If the unit is out in the hot sun, it will have to work harder to cool and will sometimes shut off during the warmest part of the day because it is too hot to operate. The air conditioner unit should be shaded by vegetation or a screen constructed of wood slats.

If the air conditioner's main motor goes out, it is best to replace it with a permanent split capacitor type; and if the air conditioner unit is replaced, the new model should have an energy efficiency ratio (EER) of at least 8.

There are several devices on the market to boost the efficiency of the air conditioner unit; however, we have not had the opportunity to test them.

APPENDIX F

UTILITY BILL SURVEY

ELECTRICITY

As part of the Energy Conservation Project the City staff and Living Systems conducted a survey of energy use in apartments and houses in Indio. A sample of 19 houses was selected and it was found that the average electrical use was 14,856 KWH/year, while the average cooling season use was 8,828 KWH/year. The table below shows the electrical and gas use for each house in the sample.

INDIO UTILITY DATA 73-75 SINGLE FAMILY DWELLING

Unit #	Orien.	Floor Area	Ave. KW/yr.	Ave. KW Base/yr.	Ave. KW Cool/se.	Ave. Thms/yr.	Ave. Thms/bs.	Ave.thms Heat sea.	Insulation Walls	Roofs	
1	N.	1270	12596.7	6346.7	6247	712.3	301	412	0	R-11	
2	N.	1050	13066	5552.0	7514	639.7	323.4	316.3	0	8"	
3	N.	1100	12843.3	5402	7441.3	814.7	254.6	560	0	6"-8"	
4	N.	1600	18576.7	9800	8776.7	639.7	237	402	R-11	R-11	
5	S.	1000	8620.5	4015	4605.5	406.7	250	156.7	R-11	R-11	
6	S.	950	15340	6046	10050.7	666	420	666	R-11	6"	
7	N.	1676	18550	4260	14290	946	306	640	R-11	R-11	
8	S.	2426	22665	10768	11897	953.5	418	535.5	R-11	R-19	
9	S.	1500	18326.7	7584	10742	863.7	420.7	444.3	R-11	R-19	
10	N.	1676	18020	6846	11174	731.5	367.5	364	R-11	R-11	
11	N.	1800	17113	7696	9417.9	631	406	225	R-11	R-11	
12	W.	1200	8465	3700	4765	643	246.5	396.1		6"	
13	E.	2250	1200.3	5074	6929.3	625	163	462		R-13	
14	E.	1200	15130	5730	9400	660.5	242.3	418.5	0	6"	
15	W.	1175	16626.7	6973.3	9586.7	729.7	414	315	0	R-11	
16	S.	700	14073	6420	7653.3	683.3	297	389.0	R-11	R-11	
17	S.	1120	12163	2674	9489.3	611	358	253	R-11	R-11	
18	S.	1120	13430	5548	8002	662.3	367	295.3			
19	N.	1200	14663.3	4910	9743.3	588.7	288	314	R-11	R-19	

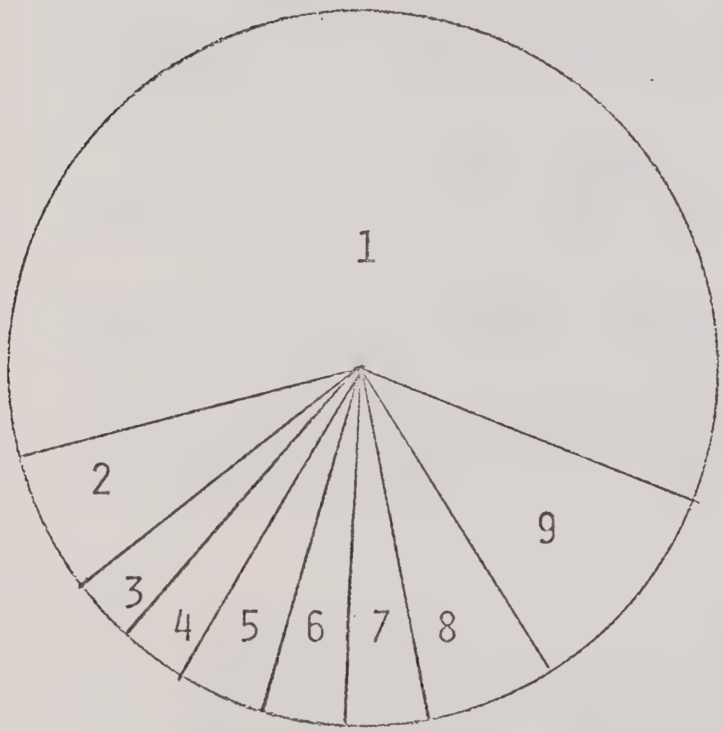
Part of the high electrical use is attributable to the extreme summer heat, but certainly the base usage should be comparable to other communities around the State. According to the Rand Report on California's Electricity Quandary, the average base use of electricity for a California household is 4,312 KWH/year. The higher use in Indio suggests that there is great potential for conservation measures. The difference between electrical use for

cooling in Indio and the average State household is even more startling - with the average State use for air conditioning only 581 KWH/year compared to 8,828 KWH/year in Indio.

It is obvious that the need for electrical power for cooling in Indio is greater then in most other climates in the State, nevertheless there is still substantial opportunity for conservation.

The following energy pie shows where Indio residents are using their electricity:

ELECTRICAL USE PIE*



1 = Air Conditioning, 60%
2 = Miscellaneous, 10%
3 = Range, 3%
4 = Dishwasher, 2%
5 = Television, 3%
6 = Clothes Dryer, 3%
7 = Lights, 3%
8 = Freezer, 4%
9 = Refrigerator, 12%

This clearly shows that even small improvements in cooling buildings can reduce electricity used for air conditioning. Shading of windows, insulation of walls and attics, and light colored roofs are the most efficient methods of keeping heat out of the house. From the first observation of the sample houses, it appeared that residents have made an attempt to shade out the sunlight. In some cases bamboo shades are being used to screen out some of the sunlight and in other cases vegetation has been used effectively to shade windows. Nevertheless only a few houses have 100% shaded windows and fewer still have shaded walls. There are some houses which have poorly shaded windows with 50% or more of the window area exposed to direct sunlight. The first step in an effective program of keeping the heat out of the house is to shade all windows. Procedures for proper shading of windows are included in the Indio Retrofit Manual. Weatherstripping should be installed around the windows and doors to prevent losses through infiltration. In addition, insulation should be added in the attics and floors. All new roofs should be white.

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* *These are approximations based on City-wide average.*

The enormous electricity usage for air conditioning in Indio homes is partly due to the inefficiency of the units. Efficiency Ratios of less than 4 were found in many of the central air units. All new air conditioning units should have efficiency levels of at least 8 and preferably higher. In addition, air conditioning units should be fully shaded to provide for more efficient operation in the summer weather. Also the location of the outside compressor can make the difference of 100% in efficiency and in some cases may prevent units overheating and stopping right at the peak hour.

The high base load usage in Indio may be minimized by purchasing more efficient units and appliances. The refrigerator is the worst offender in many households, often consuming far more electricity than the twelve percent average shown in the pie. Some refrigerators we have tested have used as much as 3,600 KWH of electricity per year in Davis, a cooler climate where refrigerators electricity use would be lower. This is more than half the base load usage in Indio. Careful selection of refrigerators can save substantial amounts of energy. An efficient refrigerator can also reduce heat added to the house by the refrigerator motor.

Clothes drying should be done on a clothesline whenever possible as a means of saving between 500 and 1,000 KWH of electricity per year. Lighting should be watched carefully and turned off when not needed.

When electricity costs reach the same level in Indio as in neighboring communities, many of the proposed conservation measures will become not only attractive but a necessity for many families. Electricity prices in Indio won't stay at 2 1/2¢ KWH for long, and as they pass through 4¢ KWH (which is representative for California) towards 9¢ KWH, which may be more typical for the future (now paid in the northeast), almost everyone will begin very careful and thorough conservation measures.

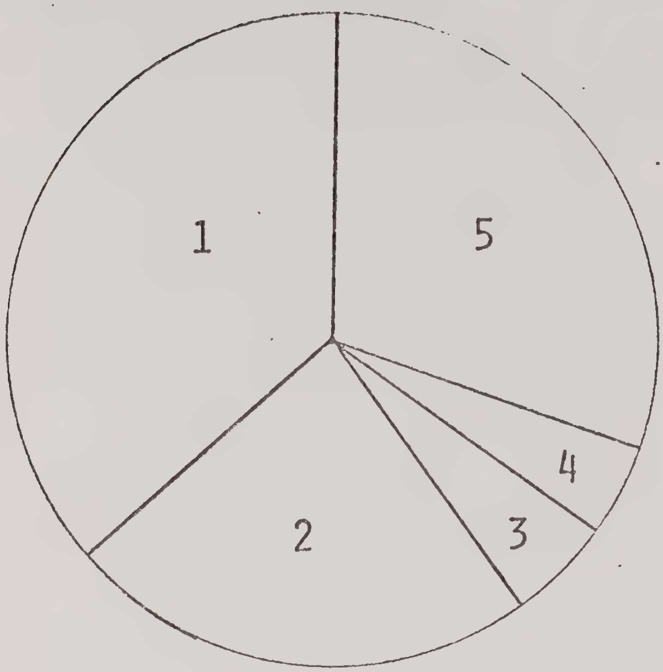
GAS

The average gas usage for the sample of 19 houses is 695 therms per year. The base usage year round is 319 therms per year and the winter usage for heating is 398 therms per year. While the natural gas consumption is relatively low compared to the majority of communities in the State, there is still potential for substantial savings.

Indio has an ideal climate for solar water heating. It is relatively inexpensive to construct solar water heating systems which would provide 90% of the need for hot water in most households.

In new construction south-facing windows should be used as solar collectors to heat the dwelling. Southermation houses in the Indio climate may save much more than 50% of the energy needed for heating.

GAS USE PIE*



1 = Hot Water, 40%
2 = Space Heating, 30%
3 = Miscellaneous, 5%
4 = Clothes Dryer, 10%
5 = Cooking, 25%

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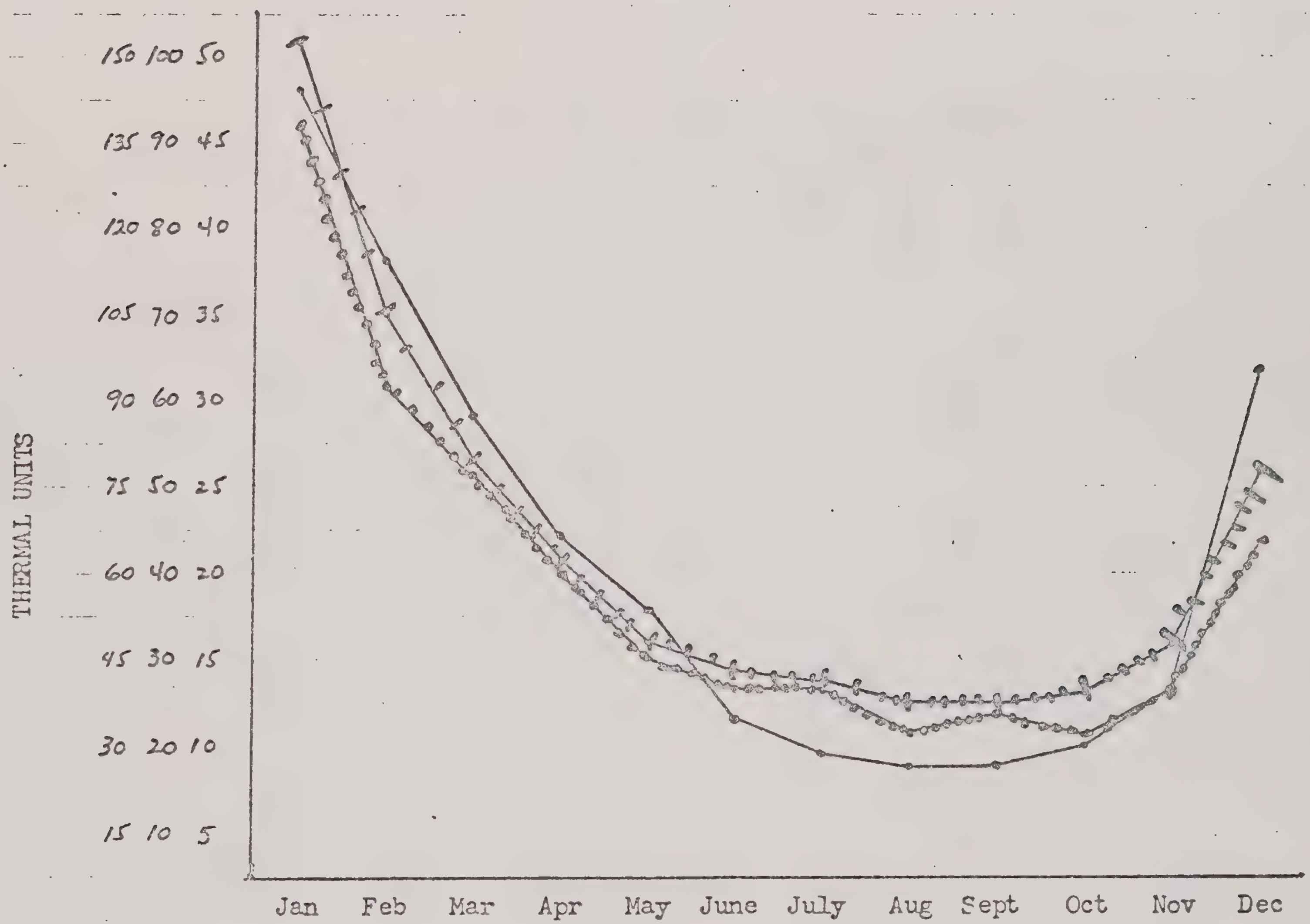
* *These are approximations based on a City-wide average.*

GAS USE



- DEMAND CURVE -

3 Year Average Monthly Consumption

Ave 44 Apartments - 10 Units
Shadow Palms Apts - 10 Units
Single Residential- 21 Units

DATA FOR INDIO HOUSEHOLD ENERGY USE PIE

	BTUs X 10^6	% of Total
Air Conditioning	99.5	41.2
Heating	41.5	17.2
Cooking Gas	13.8	5.7
Hot Water	17.8	7.4
Miscellaneous	17.1	7.1
Refrigeration	20.3	8.4
Freezer	6.8	2.8
Lights	5.2	2.2
Clothes Dryer	5.2	2.2
Television	5.2	2.2
Cooking Electric	5.2	2.2
Dishwasher	3.4	1.4
	241 X 10^6 BTU	100%

NOTE: All electric converted to primary energy consumption assuming 30% conversion efficiency on the power plant.

The average household consumes 1200 gallons of automotive gasoline at 125,000 BTUs/gallon or 150 X 10^6 BTU/year.

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